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Informal Development in Cairo, the View from Above: A Case Study Using Aerial Photo Interpretation to Examine Informal Housing in the Imbaba District of Cairo

Stevan Bullard

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by

STEVAN BULLARD

Under the Direction of Dona Stewart

ABSTRACT

The goal of this study is to apply the extraordinarily rich set of historical cartographic and remote sensing data of Cairo, Egypt to the analysis of the problem of informal development in the twentieth century. Remote sensing of urban areas has been dominated in recent years by multispectral analysis of Landsat imagery. This restricts studies both temporally and in spatial resolution. In this study an aerial photo interpretation methodology is applied to images and maps spanning two centuries of Cairo's history at a spatial resolution on the scale of individual buildings. From these techniques insights can be obtained of the political and social forces shaping the development of Cairo.

KEYWORDS: Historical cartography, Remote sensing, Air photo Interpretation, Informal development, Cairo, Egypt.

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Major Professor: Dona Stewart
Committee: Jeremy Crampton
Elaine Hallisey

Electronic Version Approved:

Office of Graduate Studies
College of Arts and Sciences
Georgia State University
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Chapter one

Introduction and study question:

Cairo in the twentieth century has experienced remarkable growth. At the beginning of the century it contained a population of 600,000 by the end of the century the population was an estimated 12 million (Stewart, 2001). The area of the city has increased from 19.5 square kilometers in 1911 to 370 square kilometers in 1999. Growth at this explosive rate creates many problems but in the case of Cairo these problems are magnified by the fact that much of this growth has been unplanned. One half of Cairo's population lives in unsanctioned housing and almost half of Cairo's residential area is informal development (Sims, 2003). Informal development, *Ashwaiiyyat* in Egyptian Arabic (Bayat, 2000), has been blamed for loss of agricultural land, severe overcrowding, and lack of access to services for residents among other ills (El-Batran, 1998).

The agricultural sector has historically been of utmost importance to the Egyptian economy. In the 19th century agricultural exports, particularly cotton, made Egypt rich but the population increases of the 20th century put a severe strain on the agricultural sector. Until 1960 Egypt was self-sufficient in food production but rising demand exacerbated by government subsidies for basic foodstuffs pushed the economy into an agricultural trade deficit (Library of Congress, 1990). Presently Egypt is one of the world's largest importers of food, particularly wheat, while still depending on exports of products like cotton and rice for much needed foreign currency (Agricultural Research Center, 2006).

In the face of this pressure on agriculture any threat to the limited resource of arable land is taken seriously. The growth of Cairo's population has put tremendous strain on the surrounding farmland. Cairo is, by American standards, an extremely compact densely inhabited place. Compared to a city like Atlanta metropolitan Cairo would fit comfortably within Atlanta's city limits. (Figure 1)

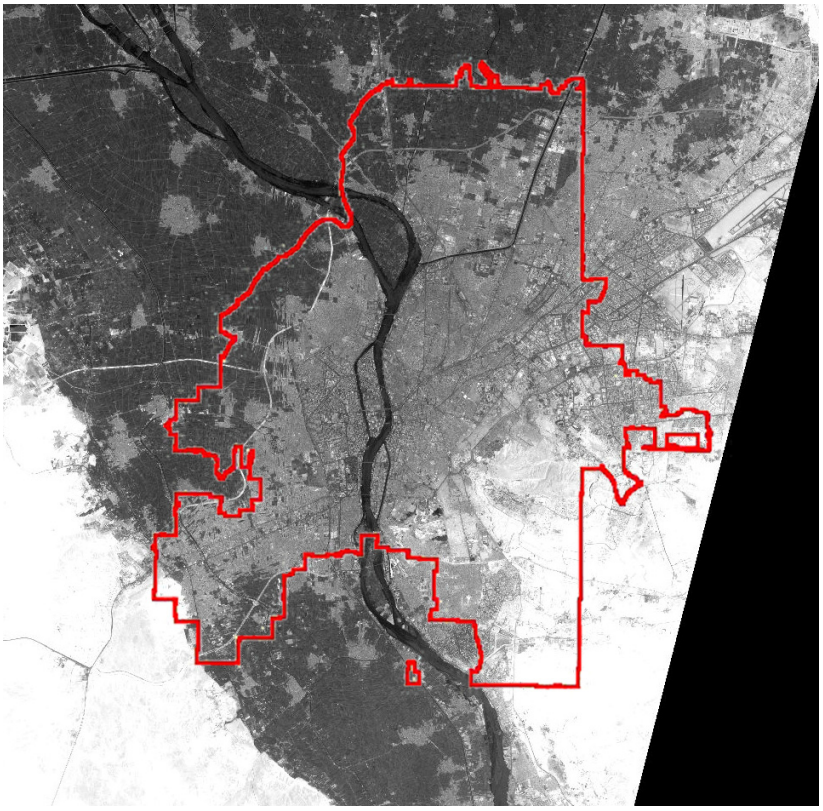

Figure 1. The city limits of Atlanta, Georgia superimposed on Cairo, Egypt.

Cairo's 10 million inhabitants live in an area that supports 400,000 in Atlanta. Increasing the density of Cairo isn't a feasible way to absorb the increase in population. So Cairo has expanded into the agricultural land. The Egyptian government has attempted to stop this loss of

arable land by passing laws that restrict building on farms (Sims, 2000). It is these laws that the informal developments ignore.

The subject of informal development has attracted the attention of geographers in recent years but very few working in the field of remote sensing has taken on the problem. The reasons for this stems from the limitations of the satellite images available to civilian geographers until very recently. Remote sensing of cities and particularly the study of growth in urban areas has relied for many years on multispectral analysis of imagery from the Landsat class of satellites. These techniques have been very successful in looking at cities in the North America and Europe but present real challenges for studies of cites in the third world and particularly those in the Middle East (Yin, 2002).

In the late 1990s two events opened up a new avenue of approach in remote sensing of cities and of Cairo in particular. First the US government gave permission to commercial companies to operate imaging satellites with a resolution of one meter or less. Then a large number of images from the earliest CIA spy satellites were declassified and made easily available to the public.

Egypt had been of great interest to the CIA so suddenly high quality images of Cairo from the 1960s were available that were readily comparable to the new commercial high resolution images. These new images gave a 30-fold increase in spatial resolution over Landsat images but at the cost of the color information available from Landsat's 6 multispectral bands. Remote sensing had moved from color back to black and white. This change required a new set of techniques of analysis. Fortunately a methodology already existed for dealing with high resolution panchromatic imagery, aerial photo interpretation. These methods, developed over

decades of looking at black and white air photos, are directly applicable to the new satellite technologies.

Aerial photo interpretation has several advantages over multispectral analysis counterbalanced by a very large disadvantage. Looking at Cairo one of the advantages is the ability to integrate historic air photos and cartography into the analysis of change over time allowing a longer time period to be studied than is possible with multispectral analysis. A second advantage comes with the increased spatial resolution. The development of informal housing occurs at a very fine grain in the urban fabric (Sims 2003). Many of the details of this development, that may be important in understanding the forces shaping it, are below Landsat's 30 meter resolution and are lost to multispectral techniques. The great disadvantage of this methodology is the demands it places on the individual analyst. Done well, aerial photo interpretation requires a high degree of expertise both in the techniques of analysis and in the subject area under study (Lillesand, 1994). This study assumes that moderate levels of knowledge don't preclude a useful analysis but recognizes that information will be available in the data that will be missed until a more expert analysis can be done.

The goal of this research then is to apply the techniques of traditional aerial photo interpretation in the context of a modern geographic information system to a long time series of images and maps of Cairo, Egypt. This study examines the dynamics of urban change in three types of development that have been important in the building of Cairo, formal/planned development, informal/unplanned development and traditional/Islamic development to answer three questions:

First, are there distinctive patterns in the rate, timing, and shape of growth that distinguish informal development from the other development types?

Second, can these patterns give insights into the forces shaping informal development in Cairo?

Finally, can these patterns be used to identify the extent of existing informal developments and help to predict the future directions of their growth in the city?

Chapter two is devoted to the literature on Cairo to give context to the types of development that have shaped the city and the particular study area of this research. Chapter three will describe the methodology used in this study and the literature on remote sensing of urban areas and change detection and analysis.

Chapter four presents the findings of this analysis. Chapter five gives the conclusions drawn from these findings and presents some questions for further study.

Chapter two

Study area and literature review for the development of Cairo:

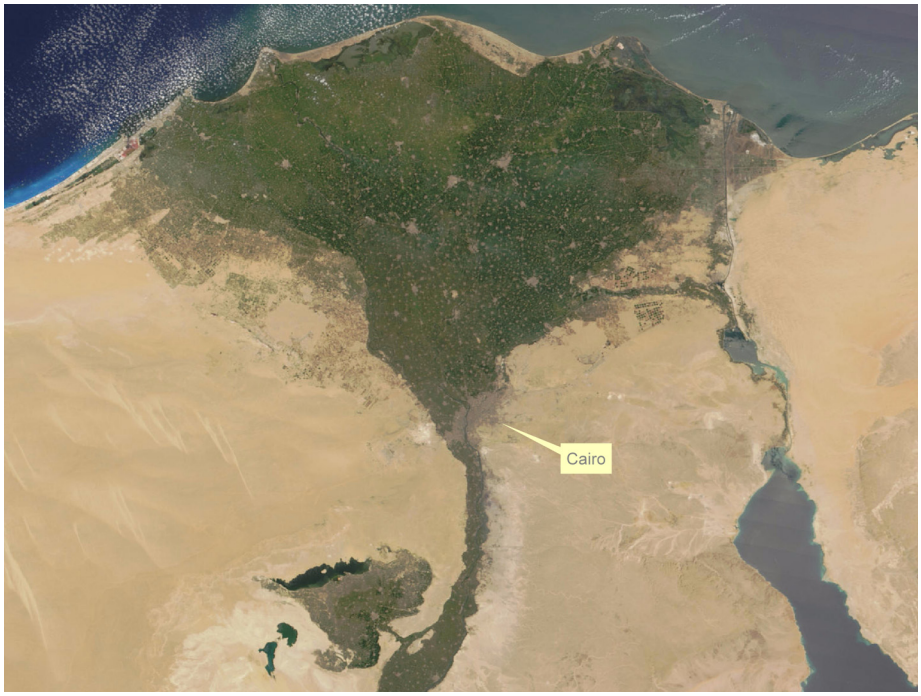

Figure 2. Satellite image of the Nile delta showing the location of Cairo.

Cairo, Egypt is located at the point where the Nile leaves its constraining valley and widens into the plain of the Delta. There has been a city at this location for at least 5000 years and probably long before that (Rodenbeck, 1999). The history of modern Cairo is somewhat shorter, beginning with the Arab invasion of Egypt in 640 AD and the founding of the city of Fustat by Amr ibn al-As (Raymond, 2000). This study of Cairo's development is concerned with only the last 200 years of this almost 1400 year history but in that period almost 90% of the present city was constructed.

This chapter will begin with a brief outline of Cairo's history with references to how the development of the city was influenced by the shifts in political forces. Then the several types or styles of development that are important in the past 200 years will be described along with

references. Finally the specific study area within Cairo that is the focus of this research will be covered.

The development history of Cairo:

The developmental history of modern Cairo can be divided into a few fairly distinct eras. The first is the Islamic period that covers the time from the city's founding until the French invasion and occupation in 1798. After the French left in 1802 an era of European influence began that includes a period of outright colonial domination lasting until 1952. In 1952 the Revolutionary period began and lasted until the end of hostilities between Israel and Egypt in the late 1970s. The current era is one of economic liberalism begun with the *Infitah* or openness policy of President Anwar Sadat and continuing under President Mubarak.

The Islamic period:

The Islamic period is the longest, most interesting, and most complex in the history of Cairo's development. It produced the greatest artistic monuments in the city and will necessarily get a very cursory treatment here. Fortunately there is a wealth of literature on Cairo's Islamic heritage. This study has relied heavily on six general works on Cairo, each with its particular approach to the city. Desmond Stewart (1968) and Aldridge (1969) take a historical approach to the city. Stewart concentrates on the early history particularly the Islamic period. Aldridge deals thoroughly with early Cairo but continues through the Colonial period into the Revolutionary period.

Golia (2004) and Rodenbeck (1999) are more concerned with the contemporary city. History serves for them as a backdrop to explain the present cultural landscape.

Raymond (trans. 2000) and Abu-Lughod (1971) look at Cairo from a geographical perspective. Raymond looks at the history of the city as it shapes the functional areas, the markets and residential districts for example. Abu-Lughod's view on the shape of the city is demographic. She is most concerned with how the sociology of the residents has influenced the built environment of the city. This brief outline of Cairo's early history relies mostly on Raymond and Aldridge.

Medieval Cairo was built over the course of 1100 years as a series of dynastic compounds stepping northward into the prevailing wind, each one moving away from the odors of the existing city. The first settlement, Fustat, began as an encampment for the Arab army that conquered Egypt for Islam in 642. Built outside the Roman fortress of Babylon that controlled both the bridge across the Nile and the traffic up and down the river, Fustat prospered as a trading center and grew to be large and important city (Raymond, 2000).

Control of Egypt passed to the Abbasid dynasty in 750 and in 752 the new rulers began construction of an administrative compound called al-Askar just north of Fustat. In 868 Ahmad ibn Tulun became the ruler of Egypt beginning the Tulunid dynasty. Ibn Tulun built his own administrative center, al-Qatai north of the expanded city of Fustat which had grown to encompass Al-Askar. The Tulunids are in due course supplanted by a return of the Abbasids. The Abbasids destroyed much of al-Qatai leaving only the mosque of ibn-Tulun. The next important dynasty to shape Cairo, the Fatamids arrived in Egypt in 969 and founded their new city five kilometers north of Fustat. Called al-Qahira, the victorious, it was much larger than al-Askar or al-Qatai and more permanent. The boundaries of al-Qahira and Fustat defined the extent of Cairo until the 19th century. The city evolved greatly within those boundaries over the next 800 years but the area remained basically unchanged. Figure 3 shows the locations and area

of Fustat and its extensions and figure 4 shows the extent of Cairo at the arrival of Bonaparte in 1798.

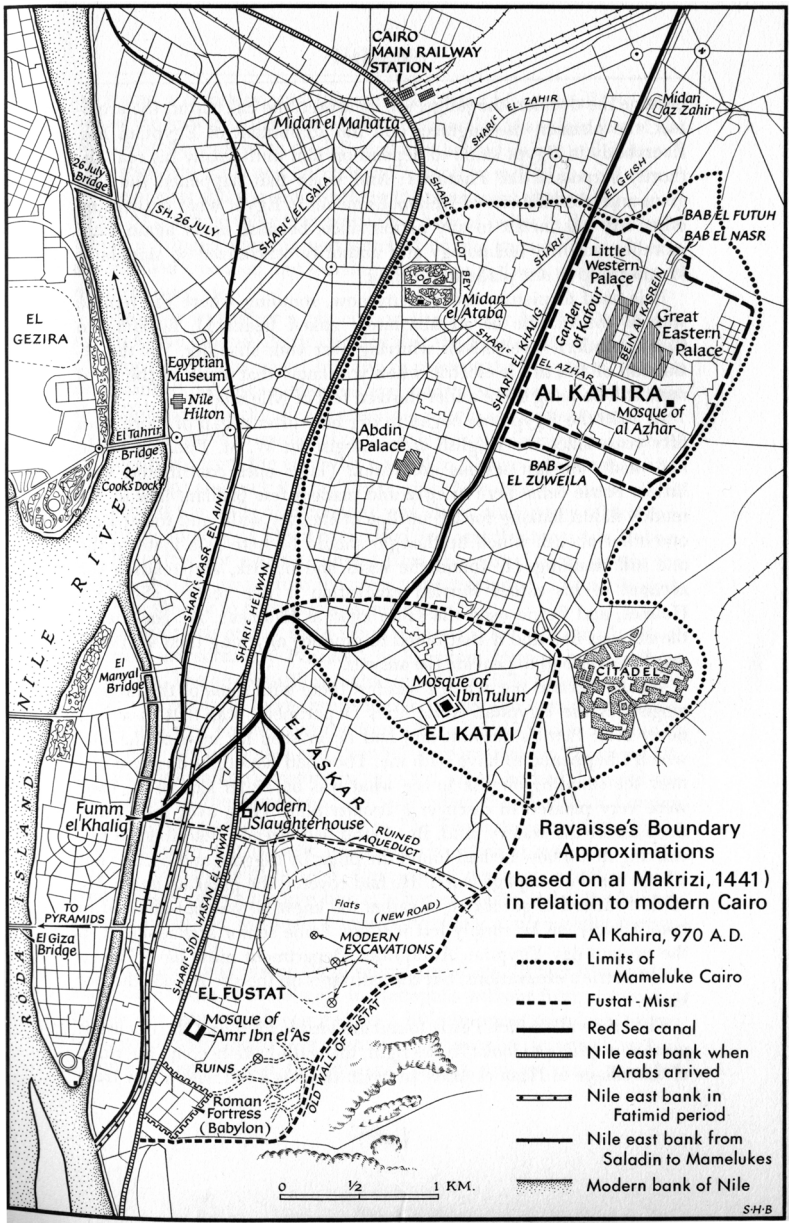

Figure 3. Fustat, el-Askar, el-Katai, and al-Kahira. (Aldridge, 1969, p20)

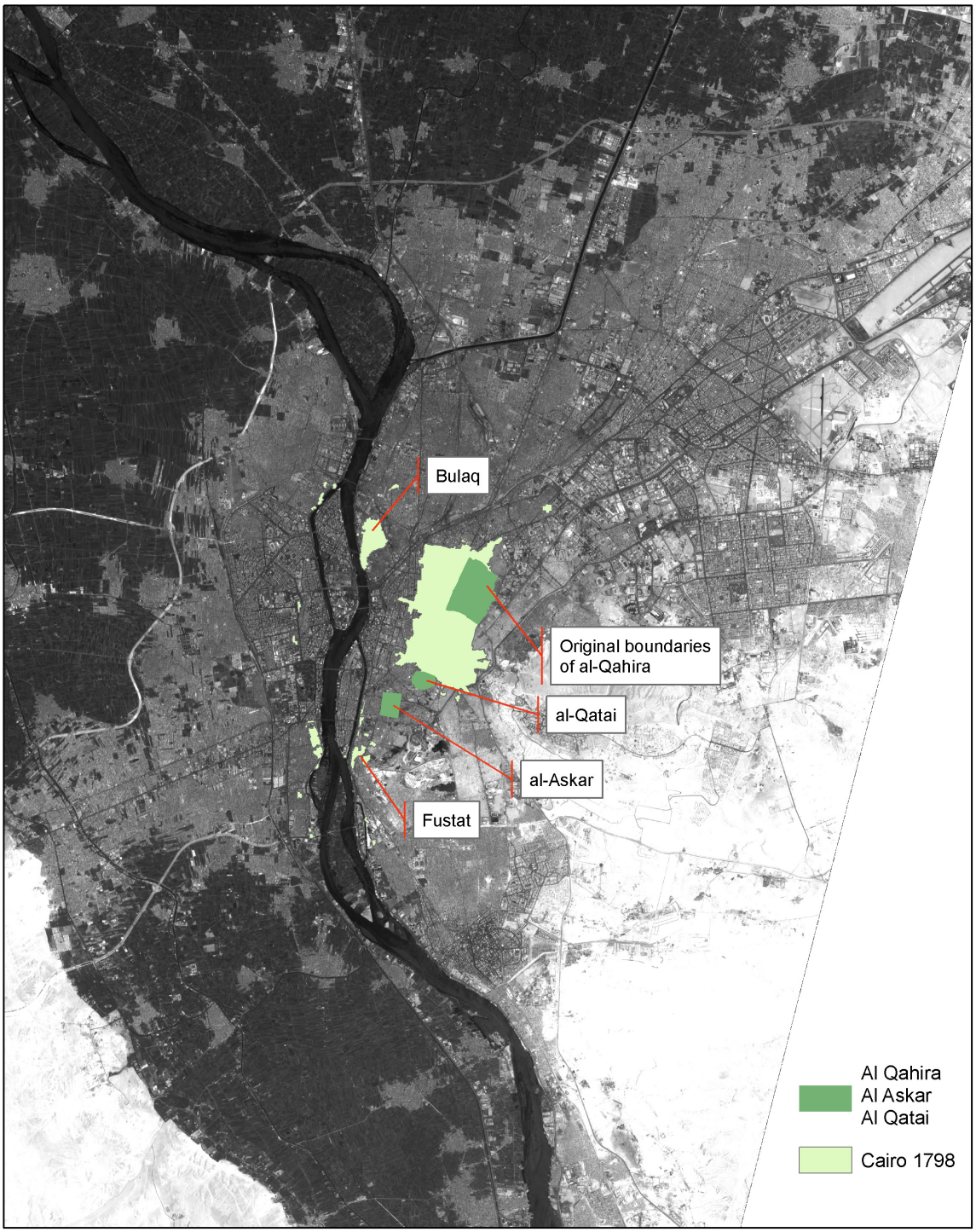

Figure 4. The location and extent of medieval Cairo overlaid on a 1999 satellite image.

European Influence and Colonial Period:

The modern era in Cairo is generally dated from the French occupation that began in 1798 (Raymond, 2000). Napoleon's army held Cairo for only three years before they were ejected by a combination of rebellion by the Egyptians and defeat at sea by the English. The French occupation was momentous for Cairo in two ways. Napoleon took back to Europe an intense interest in all things Egyptian that persists to this day, which helped to fuel the colonial interest of Europeans. In the power vacuum that was left after the French retreat a new ruler emerged that turned Egypt toward the West. Muhammad Ali, an Albanian officer in the Ottoman army that reoccupied Cairo after the French leave, became the ruler of Egypt within four years (Aldridge, 1969). He and his successors brought in the English to build railroads and the French to build the Suez Canal. Perhaps even more importantly Muhammad Ali introduced cotton as a cash crop to Egypt (Aldridge, 1969). Egyptian cotton became an important raw material for English mills and when the American Civil War cut off supplies of Southern cotton the Egyptian economy boomed (Abu-Lughod, 1971). This newfound wealth and the opening of the Suez Canal inspired Muhammad Ali's grandson Isma'il to begin the first great development scheme in Cairo since the building of Al-Qahira in 969. Isma'il Pasha had been educated in Paris and was impressed with French ideas of urban design. To build a suitable capital to host the dignitaries coming from Europe for the opening of the Canal he brought French designers to Cairo, beginning in 1864, to build his new city (Raymond, 2000). Figure 5 shows Isma'il's additions to the city and the area of the Islamic city from Napoleons map of 1798 overlaid on a satellite image from 2005.

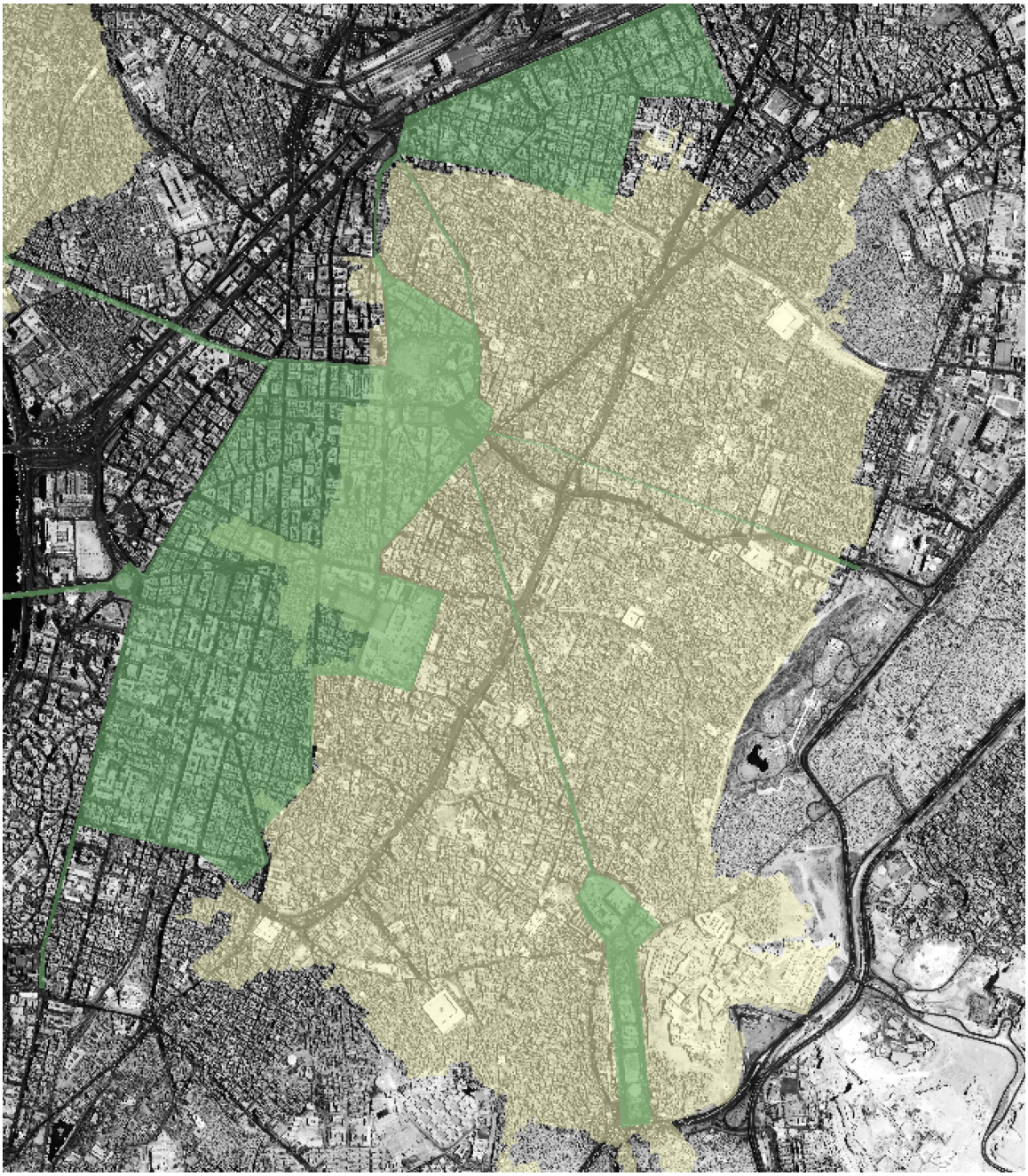

Figure 5. The additions to Cairo by Isma'il Pasha are shown in green, the medieval city is in yellow overlaid on a satellite image from 2005.

The difference in the layout of the streets is very evident. The broad straight boulevards of the European design contrasting with the dense convoluted streets of the medieval city.

The building programs of all of Muhammad Ali's clan including the railroads, the canal, and finally Isma'il's new city plunged Egypt far into debt to European banks. The opening of the Suez Canal as a direct route from Europe to India made Egypt strategically supremely important to Britain. In 1875 to prevent French control of this vital link in the Empire, Britain purchased Egypt's interest in the Canal from a cash-strapped Isma'il. Finally in 1884 using Egyptian insolvency as an excuse England took full colonial control of Egypt.

Britain's control of Egypt lasted until 1954 (Raymond, 2000). Like the great powers that had controlled Cairo in the past, the Ottomans and the Arabs, Britain left two great monuments to mark its reign. Unlike the past these were not mosques or fortifications but engineering works; the Aswan dam and the irrigation system that distributed the dam's waters. Tvedt (2004) outlines the British relationship to the Nile that resulted in the building of these monuments.

In addition to the strategic position of Egypt as the gateway to India the cotton crop was of equal importance to Egypt's new rulers. To maximize the return on cotton it was necessary to control the waters of the Nile (Tvedt, 2004). The English reconstructed the Nile barrage first built by Muhammad Ali in 1847 to provide irrigation for cotton (Aldridge 1969). This proved insufficient for British needs so by 1902 they built the Aswan dam and a system of canal based irrigation to replace the basin irrigation practiced since Pharonic times (Tvedt, 2004).

The dam was to have a profound unintended impact on the shape of Cairo's development. Before Aswan was built the city was limited to the desert margins above the agricultural land on the floodplain of the Nile. Swollen by rains in the Ethiopian highlands the river would rise in June of each year and flood the fields with several feet of water. The annual

inundation of the river had irrigated and fertilized the valley and delta since time immemorial. This flooding prevented any permanent structures from being built on agricultural land. The Aswan dam ended the annual flood and almost immediately people began to build on the formerly agricultural fields (Abu-Lughod, 1971).

Under the British improvements were made to the infrastructure of the city. Between 1894 and 1917 a streetcar transit system was built. Three bridges were built across the Nile starting in 1902, once the course of the river was stabilized by the dam, and finishing in 1907. A sewer system was begun in 1907 that served the city into the 1960s (Raymond, 2000). The increasing success of the cotton economy brought a large number of foreigners to Cairo (Raymond, 2000). Two world wars, with Cairo as the center of British operations, also brought large contingents of western troops (Aldridge, 1969). The presence of so many foreigners increased the tensions in Egypt and finally led to a popular uprising in 1952.

Revolutionary Period:

The Revolutionary period of Egyptian history begins in 1952 with the burning of European Cairo. After the popular uprising, power shifted to a group in the Army known as the Free Officers led by Gamal Abdel Nasser. The Revolutionary period is marked mainly by war. The Suez invasion of 1956, the six day war in 1967 and the Yom Kippur War in 1973 all drained resources from the government. The great project of Nasser's early years, the building of the Aswan High Dam, cemented Egypt's relationship with the Soviet Union. This relationship encouraged the government to adopt policies of "Arab Socialism" which included the building of low-income housing on a Soviet model (Wheelock, 1960).

Infitah, Period of Openness:

The end of hostilities with Israel and the Camp David Accords ends the Revolutionary period. The period of Arab Socialism had left Egypt with unproductive industries and trade only with the countries of the Soviet block (McDermott, 1988). In the hope of reviving the economy Sadat began to liberalize access of foreign capital to Egypt through a policy of openness to the West. One result of these policies was the emigration of thousands of Egyptian workers to the oil rich states of the Persian Gulf (Oweiss, 1990). The remittances from these workers add billions of pounds to the economy. Because of inflation much of this capital was invested in durable goods (Lippman, 1989). Much of this investment was channeled into housing in the informal economy causing a boom in building in the 1980s (Sims, 2000).

Development types in Cairo:

This study focuses on informal development but this is just one of several types of development that are important in the building of Cairo. This section will out line three principal types of development, formal, government sanctioned development, informal, illegal development usually associated with slum dwellings, and Islamic style development. There is extensive literature on the Islamic form of development of cities and of the informal development type particular to Cairo but literature on formal development in Egypt is somewhat limited.

Formal Development:

Formal development by definition involves participation by the government either directly in the planning process or in the granting of permits and so is most sensitive to changes

in the form of government. Each of the historical periods outlined above has had a different approach to planned development.

The present layout of medieval Cairo looks quite chaotic but the city began its history as a formally planned royal compound. Many of the great Middle Eastern cities began as royal enclosures with the city plan established by decree at the founding. Alsayyad (1991) describes the planning of these royal Capital cities. The traditional Muslim city may begin with a formal plan but it undergoes an evolutionary process over the course of its history (Serjeant ed., 1980). By a process of infilling and gradual replacement the formal layout is transformed to the winding narrow convoluted form that is characteristic of traditional Islamic cities. After 1000 years almost no vestige of Cairo's original plan remains in the cityscape (Alsayyad, 1991).

While it seems reasonable in the medieval period for a city to be planned by royal decree it is surprising that this form of planning is repeated at the beginning of the era of European influence in Cairo. In 1867 when Isma'il begins construction of the European inspired quarter of the city he still has sufficient power, particularly economic power, to impose a design on the city (Abu-Lughod, 1971). No subsequent Egyptian government will have the power to repeat this form of planning.

In the British colonial period planned development became more complicated. Before 1949 Cairo did not have a city government, municipal functions were carried out at the level of the national government (Abu-Lughod, 1971). Planning in the city was carried out by the Tanzim department of the Ministry of Public Works. The best source on the working of the Tanzim during the first half of the 20th century is Volait in Nielsen, ed. (2001) Much of the formal development in Imbaba is carried out in this period and Voliat is the only source that describes these developments in any detail.

Much of the new development in the city during the colonial period was private. Districts like Heliopolis, Garden City and Zamalek were built by private companies for elite clientele. Public development plans were made by the Tanzim for low income housing, particularly intended for displaced workers from the proposed rebuilding of Bulaq, the medieval port of Cairo which was considered an eyesore (Nielsen ed., 2001). The colonial government provided little economic support to these plans so very few were actually built when the ambitious renewal of Bulaq was abandoned (Abu-Lughod, 1971).

The Revolution brought a new concern for low income residents of Egypt. Land reform was undertaken to breakup the large agricultural estates and redistribute the land to peasants. In Cairo there was an effort to build low and moderate income housing. After Nasser visited the Soviet Union these housing developments came to be modeled on Soviet style apartment blocks (Wheelock, 1960). These buildings, in the International style of Le Corbusier and the Bauhaus, are associated in Cairo with Nasser and are referred to as Nasserist.

In the period following peace with Israel and reopening of ties to the west the types of formal development for low and moderate-income groups changed significantly. The inadequacy of the previous efforts had increased the levels of informal development which put great pressure on agricultural land. To preserve the agricultural sector the government built satellite cities in the desert to absorb increases in urban population. The best description of the development of the new cities is in Stewart (1996). Again formal development failed to keep pace with demand for housing and informal development in the city increased in the 1970s and 1980s (Denis, 1997).

Informal development:

According to Denis (1997) the orthodox view of unplanned development is that they are slums, inhabited by immigrants from the countryside, havens for crime and Islamic fundamentalism. Informal development has been associated with slums by Sims (2003). He identifies four types of slums in Cairo, two of those types are informal developments, developments on agricultural land and developments on state owned desert land. These two types of informal development are quite distinct and this study deals only with developments on agricultural land (El-Batran, 1998).

Bayat and Denis (2000) looked at the demographics of informal districts and found a different picture. They noted that rural migration to Cairo has slowed greatly beginning in the 1970s. The migrants to informal districts were more likely to be moving out from the city core and to include professionals, civil servants and unemployed university graduates (Bayet, 2000). The residents were not likely to be squatters. The housing was usually owner built or built by subcontractors for the owner on plots purchased from a farmer subdividing his land (El-Batran, 1998; Harris, 2002). Buildings are typically multistory concrete frame structures with walls infilled with red brick. (Figure 6) The frames are constructed so that floors can be added incrementally as the family grows (Sims, 2003).

Informal developments differ from planned developments in that there is no provision for infrastructure; streets, water supplies, sewers, schools, etc. are all lacking (Sutton, 2001). There is also no formal legal paper work to prove and enforce ownership. The residents rely on trust and community mores (Sims 2003).

Figure 6. Informal housing on agricultural land. Steel reinforcement bars on the roof are for future additions of more floors.

Islamic development:

The idea that there is a typical Islamic form of development is somewhat controversial (AlSayyaad, 1991). That there is a common look to the layout of medieval Islamic cities, particularly the residential districts, is more accepted (Abu-Lughod, 1971). Figures 7 and 8 show the layout of streets in Cairo that is associated with Islamic forms. The narrow, winding, dead-end streets are typical of residential districts of traditional Islamic cities (Akbar, 1988).

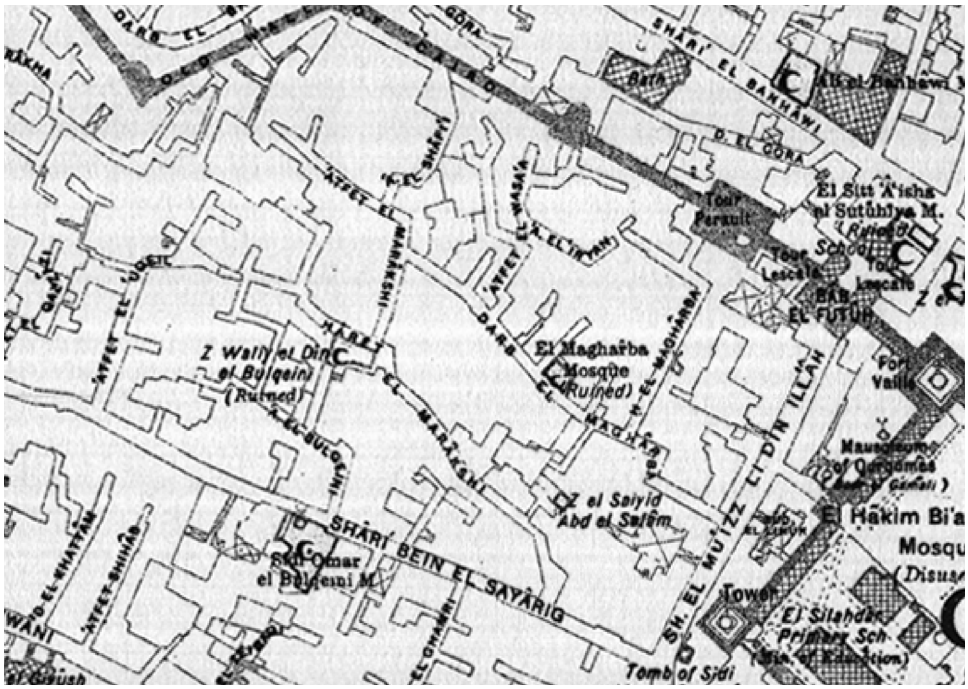

Figure 7. Street pattern in the medieval section of Cairo near the Bab al Futuh gate.

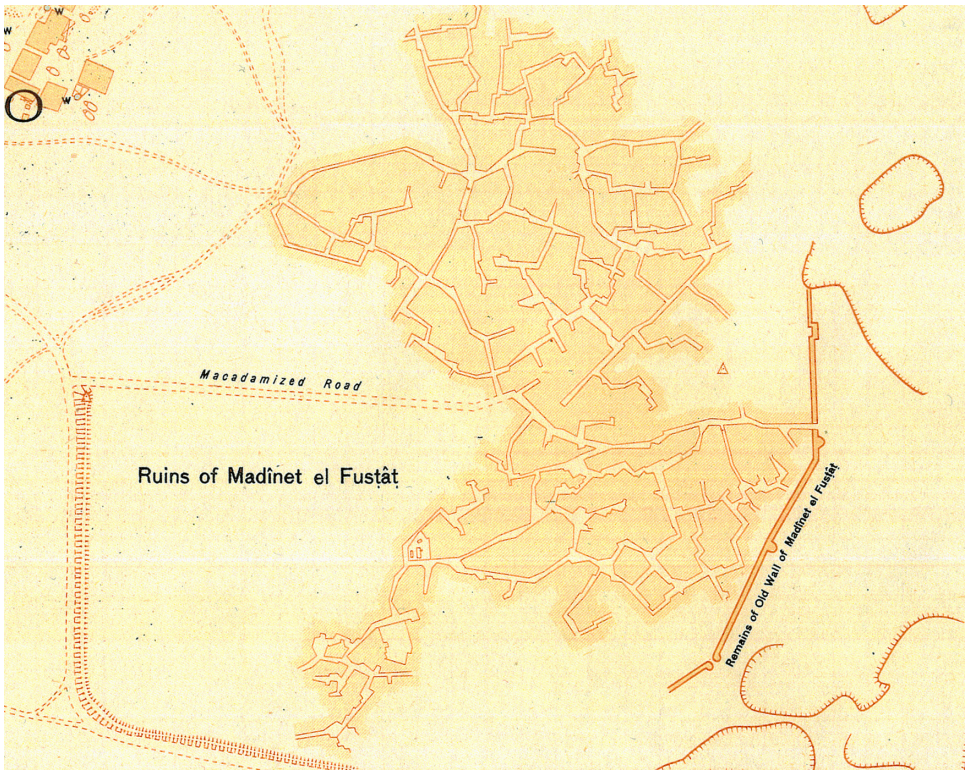

Figure 8. Street pattern in the excavations of Fustat

This pattern seems to come about by evolution and is not influenced by the geographic location or type of governing authority of the city. (Abu-Lughod, 1971; Akbar, 1988). Part of the process is driven by functional needs of transportation and climate. Narrow streets can accommodate camels but provide shade from the harsh sun (Serjeant ed., 1980). According to Akbar (1988) the principal force shaping this form of development is Koranic, Sharia law that governs the relations of neighbors and the building process. This incremental evolutionary process of building relates the traditional Islamic residential district to the informal developments of the twentieth century. The process seems to be similar to informal development in that there is no regulation by the State and buildings are built by individuals without a preexisting plan. This raises the question of why informal developments do not follow the physical form typical of traditional developments.

Study Area:

This research will examine these development types using very high resolution aerial images. This level of detail makes looking at the entire city unfeasible. By limiting the study to a single district that is representative of the development history of the city as a whole the amount of data becomes more manageable. This study focuses on the Imbaba qism (plural *aqsam*) of metropolitan Cairo. Egypt is divided for administrative purposes into Governorates. The Governorates are divided into aqsam, which are further subdivided into shiyakhat (plural *shiyakhah*) (Harris, 2002). The city of Cairo spans three Governorates, Giza, al Qahirah, and al Qalioubiya. The Imbaba qism is located in the Giza Governorate on the western bank of the Nile north west of the central districts of Cairo and is centered at 31°12’ 25” E and 30°4’41” N.

Imbaba is made up of 10 shiyakhah, which range in size from 2.23 hectares to 200.9 hectares. The shiyakhah of Imbaba ranged in population in 1996 from 1371 to 330,793. (Figure 9)

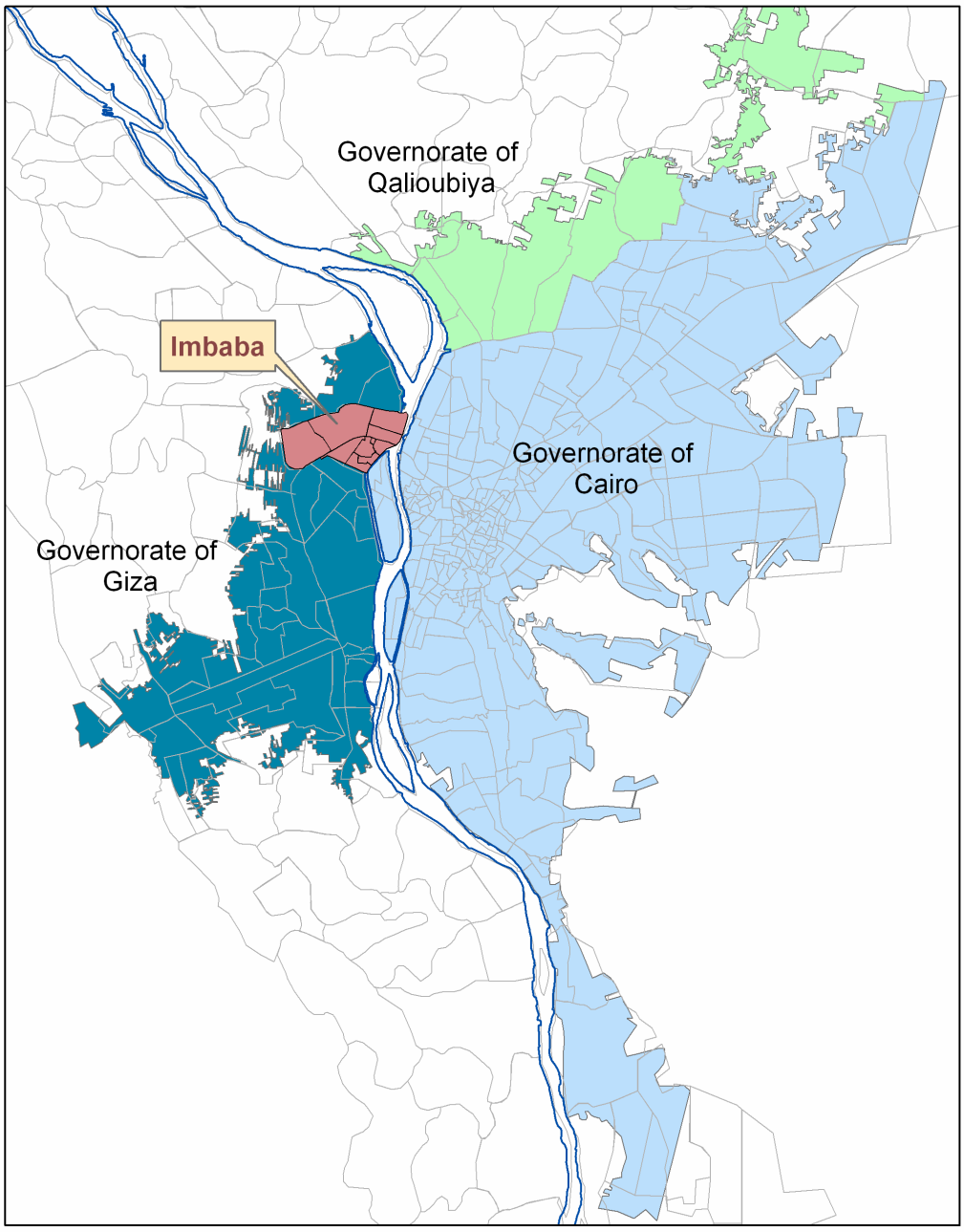

Figure 9. Location of Imbaba qism, the built up area of Cairo in 1996 is shown in color divided into Governorates. Shiyakhah boundaries are shown in grey.

Imbaba was chosen as the focus of this study because almost all of its development occurred during the period for which we have good spatial data in the form of maps and aerial images. It also has one of the most diverse development histories of the city's districts. In recent writing on Cairo Imbaba is invariably referred to as a slum. (Rodenbeck, 1999) Though the largest part of Imbaba is made up of informal housing, the qism as a whole contains most of the types of development that Cairo experienced in the 20th century. Imbaba began the century as a small agricultural village, which represents the traditional Islamic urban form. It then developed a significant middle class planned community after World War Two. After the revolution of 1952 housing blocks in the Nasserist model were built. Since the 1970s the informal settlement has expanded to fill all of the remaining land in Imbaba. This variety makes Imbaba a good microcosm for Cairo as a whole. Techniques of analysis that work for Imbaba should be applicable to the entire city.

Chapter three.

Methodology and Literature Review:

This study looks at the growth of informal developments in Cairo using methods derived from aerial photo interpretation applied to high resolution satellite images and supplemented with historic maps and data from the census of Egypt.

Remote sensing of cities is almost as old as photography itself. The first aerial images were made in France in 1858 by “Nadar”, pseudonym of Gasper Felix Tournachon. (Figure 10) (Estes, 1998 p 1)

Figure 10. Cartoon from 1862 showing aerial photography from balloons.

The first aerial photograph in the United States was of Boston in 1860, also taken from a captive balloon. (Figure 11)

Figure 11. Boston 1862

The military utility of aerial photography was realized almost immediately. The Union army in the American Civil War used balloon photography for reconnaissance of Richmond in 1862 (Am. Soc. of Photogrammetry, 1960). The invention of the airplane and the beginning of the First World War boosted the importance of aerial photography. During the war many photo interpreters were trained who went into civilian occupations after hostilities ended taking the use of aerial photography into new fields including urban planning.(Am. Soc. of Photogrammetry, 1960).

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The Second World War produced a similar influx of new photo interpreters and the promise of photography from space made the future seem very promising for remote sensing in the 1960s (Am. Soc. of Photogrammetry, 1960).

The Cold War between the U.S. and the USSR caused a split between the civilian and military communities' uses of remote sensing as aerial imaging moved into the space age. The military, in great secrecy, developed satellites that operated at high resolution but civilian agencies were limited by Congress to satellites of low spatial resolution, 60 – 30 meters per pixel. In compensation these satellites, Landsat MultiSpectral Sensor (MSS), and Thematic Mapper (TM), had an increased spectral resolution, recording color in six bands from blue to medium infrared (Lillesand, 1994). These multispectral low spatial resolution images required a new method of interpretation from the high resolution panchromatic images that were the usual product of aerial photography (Lillesand, 1994).

Multispectral analysis proved to be extremely useful and thousands of studies have been undertaken using Landsat class imagery. This kind of analysis is well suited to determinations of land use and land cover over large areas. Vegetation is easy to identify in Landsat images so discrimination between urban areas and agricultural land is a frequent use. The 30 x 30 meter pixel size leads to the blending of different surfaces into a single type for each land use. For example in suburban land uses a typical pixel may contain parts of a house, driveway, lawn, trees and street. The combination of the colors of all of these gives suburban land use a distinct spectral signature (Webster, 1996). If spectral signatures can be determined for each of the land cover types of interest then automatic systems can be built that will separate and quantify different land uses (Moller-Jensen, 1998).

One requirement in the design of Landsat was that, as the satellite was upgraded from time to time, the images remain comparable. This makes Landsat an ideal platform for study of change over time. Several techniques have been developed for change detection (Sunar, 1996). Some methods compare images pixel by pixel detecting changes in reflectance for each pixel. These methods are very sensitive to atmospheric conditions and accuracy of georectification of the images (Yuan and Elvidge, 1998). Other methods separate images into regions of different landcover and then compare the extents of those areas. (Sunar, 1996)

Landsat data has been combined with other data types to extend the capability of the analysis. Frihy et al (1998) used historic maps to extend the temporal coverage of Landsat in a study of shoreline change in the Nile Delta. Lo (1997) and Lo and Faber (1997) combined census data with spectral analysis for mapping of quality of life in Athens, Ga. Yin et al (2005) supplemented Landsat images with very high resolution Ikonos images used for ground truth and calibration of multi spectral classes in a study of Cairo.

A number of studies have been done using multispectral analysis examining the growth of cities in Egypt, particularly concerned with encroachment on agricultural land. Sultan et al (1999) looked at urbanization of the Nile Delta using Landsat images from three time periods, 1972, 1984 and 1990. They determined that much of the loss of agricultural land came as the result of the growth of rural villages. Pax-Lenny et al (1996) used a "normalized difference vegetative index" (NDVI) analysis to study the degradation of Egypt's agricultural land, due in part, to increases in urbanization. They encountered some difficulty in identifying urban landuses due to confusion with bare soils and other problems. Fahim et al (1999) approached the problem of identifying urban expansion by using images from the SPOT satellite which has an increase of resolution over Landsat but is still a moderate 20m per pixel resolution.

Yin et al (2005) examined the problems of using Landsat for determination of urban change in Cairo. Difficulties are noted in distinguishing urban uses from desert and from fallow agricultural land. Stewart et al (2004) looking at the same Landsat images note that the construction materials common in Cairo make spectral discrimination difficult. Cairo's location at the edge of the Sahara causes a coating of sand and dust over the city that increases the difficulties of determining different landuses by their color.

Photo Interpretation:

For many years the only aerial images easily available for regions outside the US were from Landsat and Spot type satellites. Since the late 1990s this is no longer the case. Commercial companies like Space Imaging, which operates the Ikonos satellite, and Digital Globe with the Quickbird satellite make available very high resolution panchromatic imagery from anywhere on Earth. The declassification of data from the Corona and Argon spy satellites of the 1960s and 70s give geographers a second time period with 1 to 2 meter resolution images, which allows studies of change over time. These new data sources represent a quantum leap over the Landsat images but require a completely different approach to analysis.

These new satellite sources are most comparable to traditional photographs taken from airplanes. To analyze them there is a ready made methodology generally know as Airphoto Interpretation (Lillesand, 1994). With Landsat the basic unit of analysis is the color of a pixel. In photo interpretation the unit of analysis is an object on the ground, a tree is recognized as a tree a house as a house. The first task in an analysis is recognition of objects. There are many factors that go into the process of recognition such as the shape, size, and pattern of features. The tone and texture of areas are useful in looking at natural features such as vegetation, for

example discriminating grass from tree canopy. The shadows of objects can disclose their height and shape, particularly in photos taken from directly overhead. Also of great importance is the context of the site and its associated features (Lillesand, 1994).

The task of analyzing a photo becomes an iterative process. The analyst makes a tentative identification of a feature and then may consult a variety of other sources such as maps, verbal descriptions or other images to refine and confirm the identification (Am. Soc. of Photogrammetry, 1960).

This study expands on this iterative process by including some of these supplemental data sources into the primary analysis of change over time. By combining historical maps of Cairo with conventional aerial photos and the recent satellite images a picture of the growth of the area can be built. Yagoub (2004) applies this type of analysis to the city of Al-Ain in the United Arab Emirates. He terms the method "visual analysis of multi-date imagery" which emphasizes the qualitative nature of the results (Yagoub, 2004 p 1066). Photo Interpretation is used frequently to obtain quantitative results from single images but the variety of scales in the data used in constructing a time series makes quantitative comparisons problematic. Antrop and Van Eetvelde (2000) compare visual image interpretation of aerial images to Landscape analysis. Landscape studies frequently deconstruct the visual landscape to determine the construction history of a place. In this study we reverse the process building an impression of a place from a direct view of the history of construction.

The goal of this study is to determine if there are patterns in the building of the three development types that will aid in identifying each type. The first step is then to identify areas in Imbaba that represent each of the three types. Unfortunately part of the identification of these areas is looking for the very patterns that are our ultimate objective. The process involves

several iterations of looking at the available data. The results section gives a somewhat simplified view of the interlocking steps that lead to a set of conclusions.

The first step is to construct a history of the building of Imbaba from a series of maps and images. From this history zones are determined based on timing and shape of development that seem to represent the different development types. Then following Lo (1997) and Abu-Lughod (1971) census data is used to help characterize these zones to further refine the identification. Any available references in the literature that refer to specific areas are used to validate identifications. Finally patterns that are evident from the detailed history of each zone are examined to look for insights into the forces shaping each type, particularly the informal development.

The process of constructing a building history is greatly facilitated by the use of a GIS to organize and analyze the variety of data sets used. ArcGIS from ESRI is used in this study. The data used here come from a larger collection of some 24 map sets and images of Cairo ranging from 1/500 scale cadastral maps to 30meter resolution Landsat images. Of those 13 cover Imbaba and are listed in Table 1.

Table 1. Data sources used.

Source	Year	resolution	Scale	Map or Image
Napoleon's Description of Egypt	1800		1/5000	map
Survey of Egypt, Library of Congress (LOC)	1911		1/10000	map
Survey of Egypt, LOC	1918		1/5000	map
Survey of Egypt, LOC	1936		1/5000	map
German WWII aerial photograph, National Archives	1941	5-10 meters		image
Corona Satellite, USGS	1962	10-15 meters		image
KH8 Satellite, USGS	1966	2-3 meters		image
Corona Satellite, USGS	1968	2-3 meters		image
Egypt Ministry of Housing and Reconstruction	1977		1/5000	map
Landsat, USGS	1986	30 meters		image
IRS satellite	1999	5-10 meters		image
Ikonos satellite	2000	1 meter		image
Quickbird satellite	2005	.8 meter		image

Each of these data sets was acquired in a different form. Some came as digital files others as film transparencies, many of the maps were photocopies. The map from Napoleon's *Description de le Egypte* was an original print from an 1820 edition. A variety of scanners were used to convert the hard copies to digital data including high-resolution film scanners, large format sheet fed scanners and flatbed document scanners. Once the data were in digital format the process of importing the files into the GIS was the same. All of the maps and images were georeferenced to a common standard using Imagine from Leica GeoSystems. The choice of the standard image for referencing proved to cause problems. Because of the wide range of spatial extents the image with the largest extent was chosen as the standard. That was a Landsat image from 1996. The low resolution of this image made referencing the higher resolution data sets difficult. The resulting slight misalignments do not detract excessively from the analysis but could be avoided by improved technique.

Once the data are in the GIS there are several methods available for visual comparison between time periods to determine change. Fading from one map or image to another on the monitor, swiping across the monitor replacing one image with another, and flickering between two images were all used. The most successful method for comparison proved to be digitizing the boundaries of development in each time period and then using the resulting vector files as masks showing the additions made in subsequent times.

The census data used to supplement the spatial data come from the Census of Egypt of 1986. Selected portions of the census tables were translated and kindly offered for this study by colleagues in Egypt. To simplify the data and help characterize the different parts of Imbaba a factor analysis was done on the census table. Factor analysis was used by Abu-Lughod (1971) to divided Cairo into socially consistent districts. In this study factor analysis is used differently as a tool of data exploration to group traits from the census into sets that help identify social groups. (Bryman, 1994)

The census analysis was done in SPSS. An initial analysis indicated that age distribution was a dominant factor in the population. As a result age was separated out and two separate analyses were run. The inputs and results from these analyses are given in the results section.

Chapter four

Results:

The results of this study are presented in four sections. The first is a brief overview of Imbaba and its development over the study period to give some orientation to the detailed history. The second is the detailed history of the building of Imbaba using photo interpretation technique to examine 200 years of development at as fine a scale as practicable. The third section presents an analysis of the demographics of Imbaba to give context to the development history. Finally zones of Imbaba will be used to contrast the particular aspects of informal development with formal and Islamic types.

Brief history of Imbaba development:

Imbaba village dates at least from Cairo's medieval period. It was located on the west bank of the Nile across the river from Bulaq, the port town that served as an entry point for goods bound to Cairo. It is likely that Imbaba's early function was as a transshipment point for agricultural produce from the farms of the west side of the Nile on to Cairo. Contemporary Imbaba is one of the most densely populated districts in metropolitan Cairo. Figure 12 shows Imbaba as it is today. The image is from the Quickbird satellite taken in 2005. The 10 shiyakhah that make up the Qism are shown in yellow. A few features stand out, an airfield in the western shiyakhat, a few large buildings, but otherwise it is very difficult to distinguish any distinct areas in the image.

The majority of Imbaba's growth has taken place in the last 100 years. Figure 13 shows, in small multiple images, the process of building Imbaba (Tufte, 1990). Imbaba grew slowly before World War Two. The greatest part of the growth was in the Revolutionary period. In the

period after Nasser's death Imbaba has been completely filled in and development has expanded on to the north and west as informal development accelerated in the 1980s.

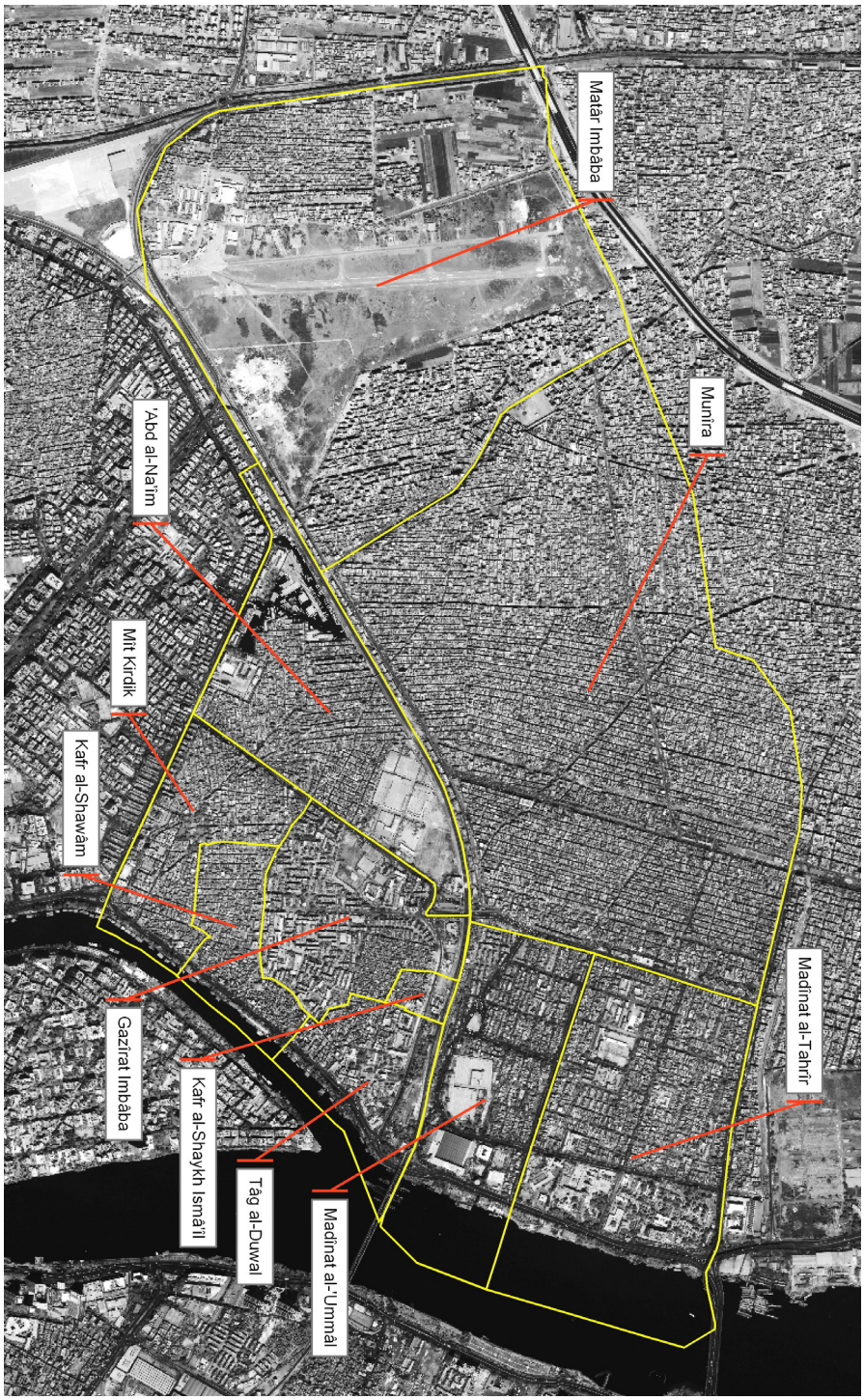

Figure 12. Imbaba in 2005.

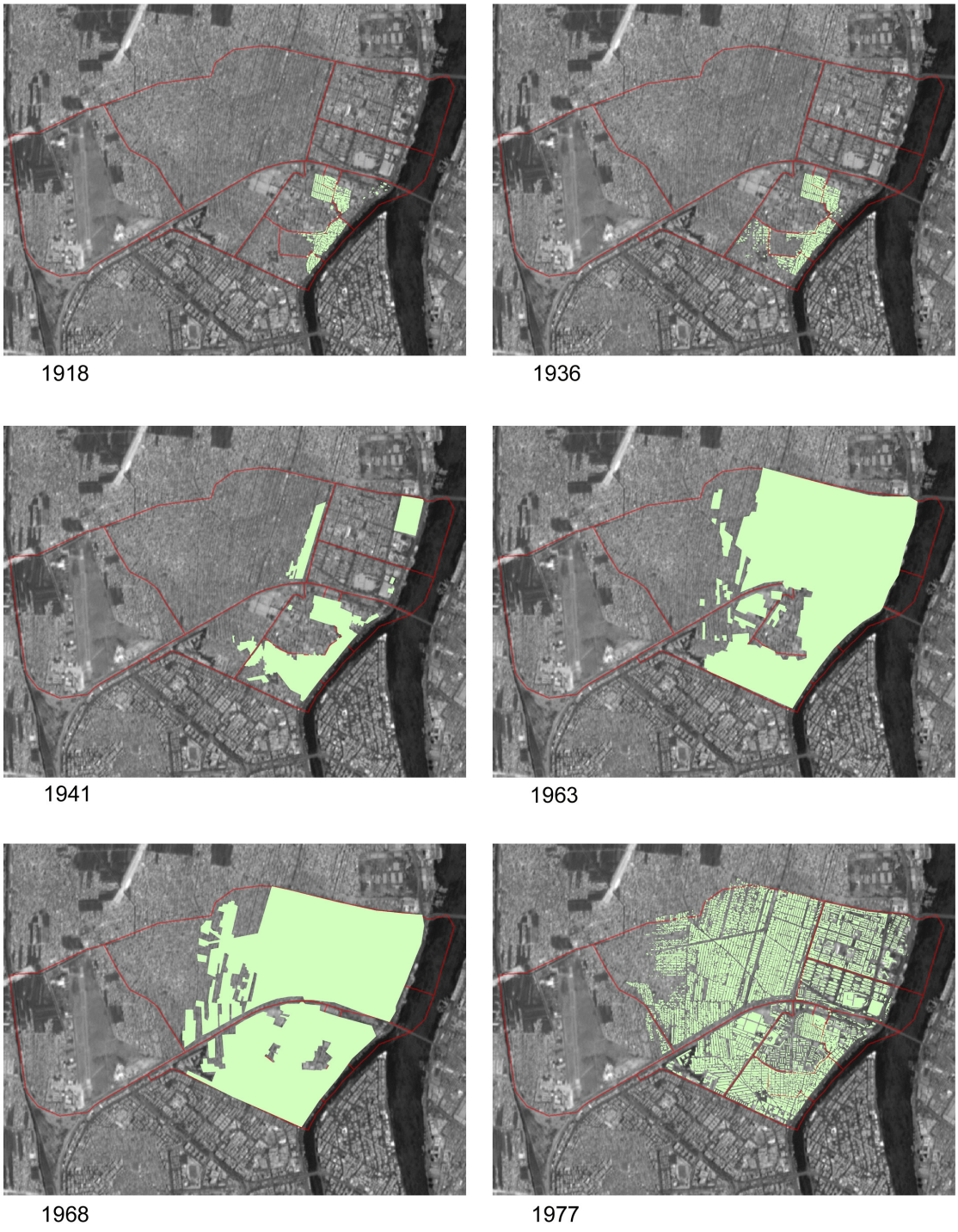

Figure 13. Building Imbaba. The background image is from 1999.

The development of Imbaba in detail.

The Islamic and Colonial periods:

The earliest map of Cairo that was drawn to strict cartographic standards serves as the base line for tracing the growth of Imbaba.. This map was made about 1800 by French surveyors during Napoleons occupation of Egypt. (Figure 14)

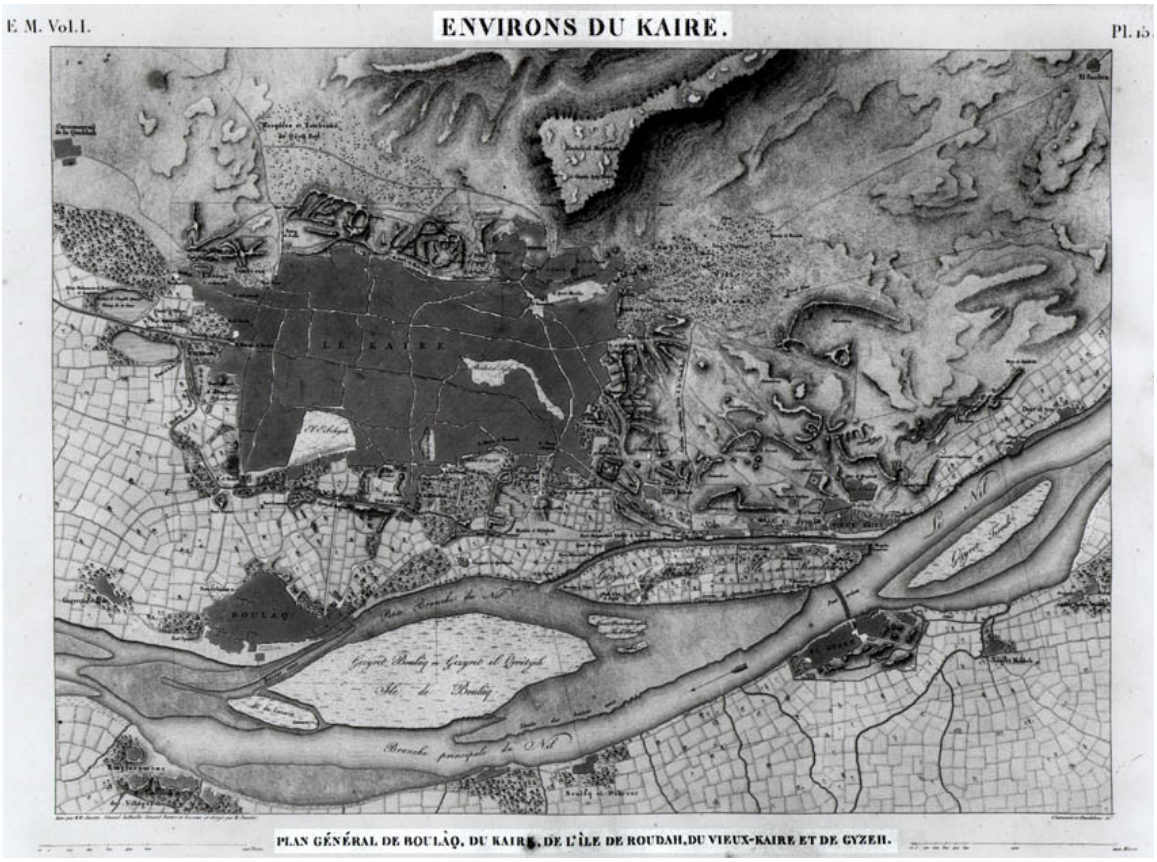

Figure 14. Cairo from The Description de la Egypte

Imbaba is shown as four small blocks on the west bank of the Nile, the lower left hand corner of the map. Figure15 shows the same map georeferenced with the outline of the modern Imbaba Qism superimposed and settlement areas highlighted in yellow.

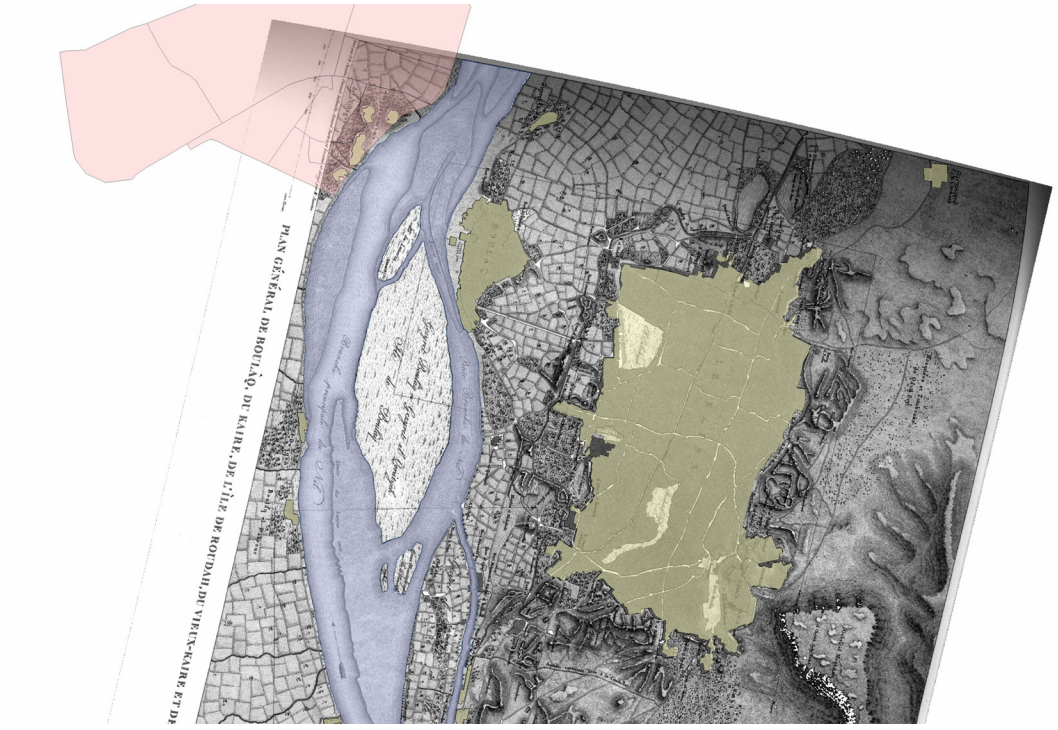

Figure 15. Cairo in 1800.

A closer view shows that the parts of Imbaba village are built on hills, indicated by the hachure around the village blocks, above the surrounding agricultural land. (Figure 16) The annual flooding of the river irrigated the farmland in the Nile valley but restricted the building of any permanent structures to higher ground above the flood level. One other feature to note is the meandering watercourses leading out of the fields. These streams provide drainage of the irrigation basins back to the Nile.

Later 19th century maps of Cairo show little change in Imbaba village. (Figures 17 and 18) The impression drawn from all of these early maps is of Imbaba as an insignificant village on the fringes of the great city, only included in the maps because it fell within the rectangular map frame enclosing the Nile.

Figure 16. Imbaba village from Napoleon's map of 1800. Present day Shiyakhah boundaries are shown in red

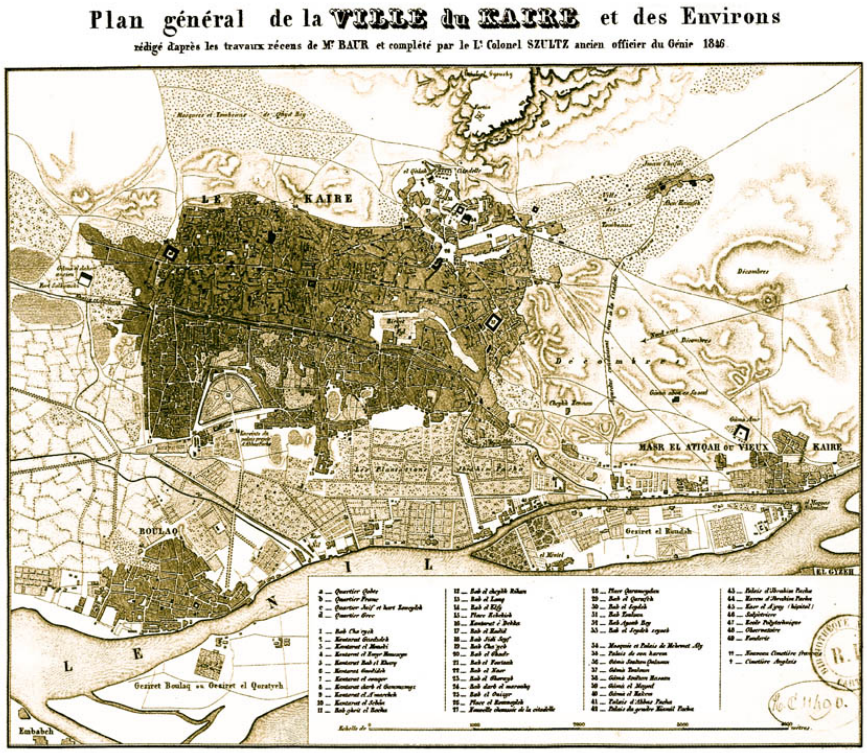

Figure 17. Cairo 1847. Imbaba in the lower left corner.

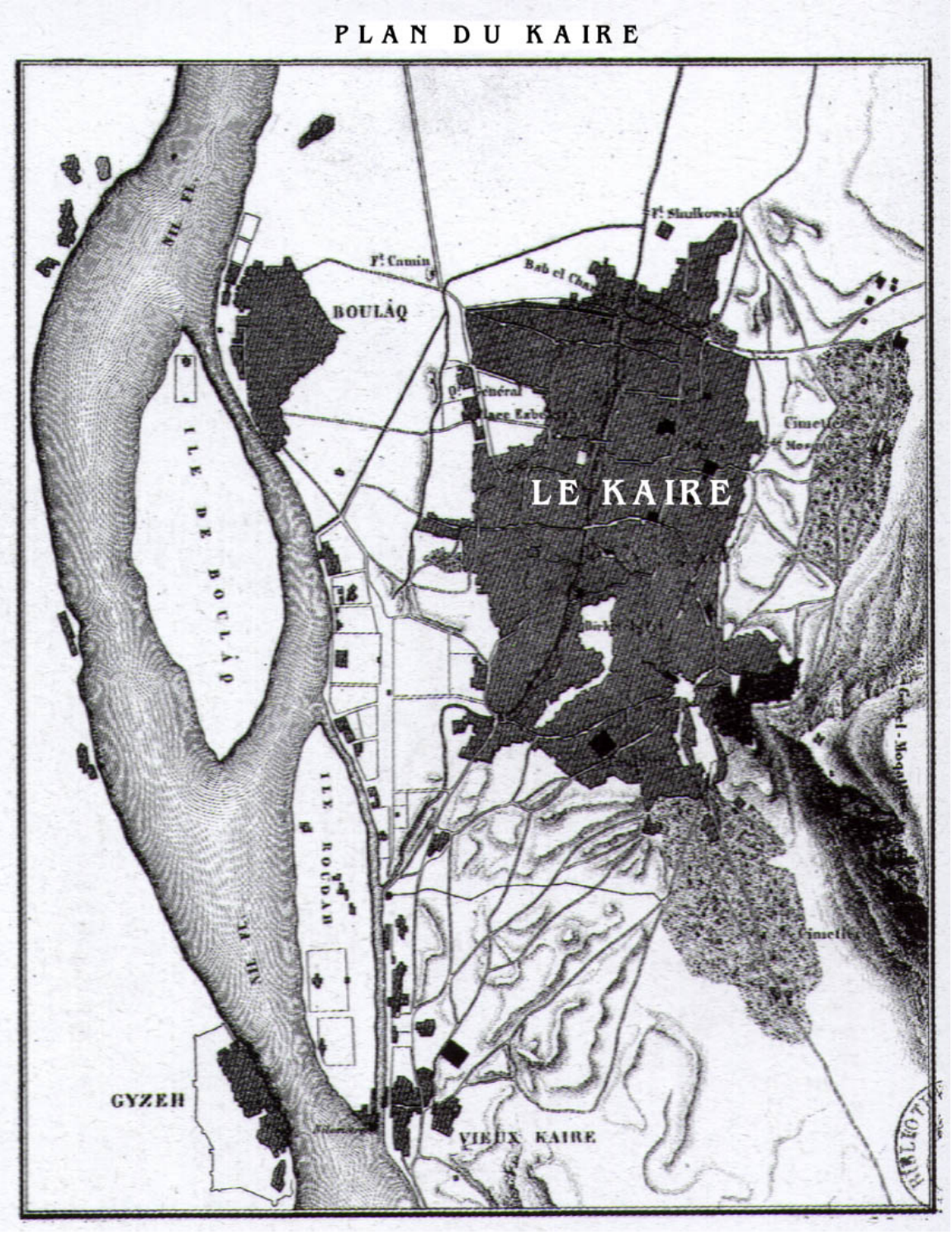

Figure 18. Cairo 1859. Imbaba is in the upper left corner.

There seems to have been little change in Imbaba during the 19th century and it's quite likely that the village has existed at that spot for hundreds if not thousands of years.

The Nile governed the physical extent of Cairo for the first 800 years of its history. The annual flood and the constant shifting of the river course limited where building was possible. The 20th century brought profound changes in the development of Cairo triggered by the completion in 1902 of the first Aswan dam. The effects on Imbaba district were immediate and begin to show up in this map of 1911 produced by the Survey of Egypt. It shows Cairo at 1:10,000 scale. (Figure 19)

Figure 19. Imbaba in 1911 with the current outlines of Imbaba Qism.

In figure 20 we see a closer view of Imbaba village from the same map.

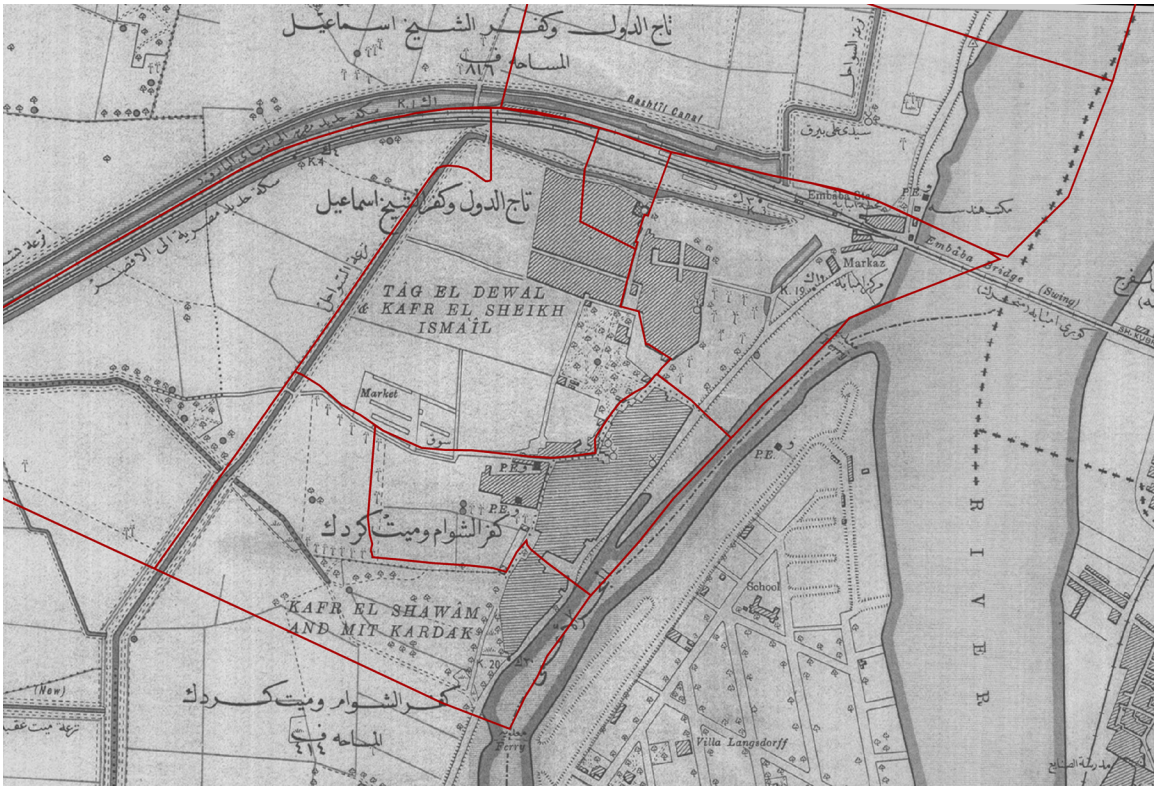

Figure 20. Imbaba 1911.

The first change to note is in the course of the Nile. The river is smaller and the channel has shifted to the west. In figure 21 the 1800 course of the Nile is shown in blue superimposed on the 1911 course. A significant amount of new land has become available, particularly the island of Zamalek which has begun to be developed by 1911. But land has also been lost in the shift of the channel. In figure 22 the 1800 extent of Imbaba village is shown over the 1911 extents. Parts of the old village have been over taken by the Nile. While the over all size of the village seems to have been maintained the location has shifted to the west.

Figure 21. Nile in 1800 overlaid on 1911 city map.

Figure 22. Extent of Imbaba village in 1800 overlaid on village of 1911.

The next change of note is the addition of a network of irrigation canals and drains to replace the irrigation effects of the annual flood and the meandering streams that drained the landscape 100 years before. These are shown in blue on figure 23.

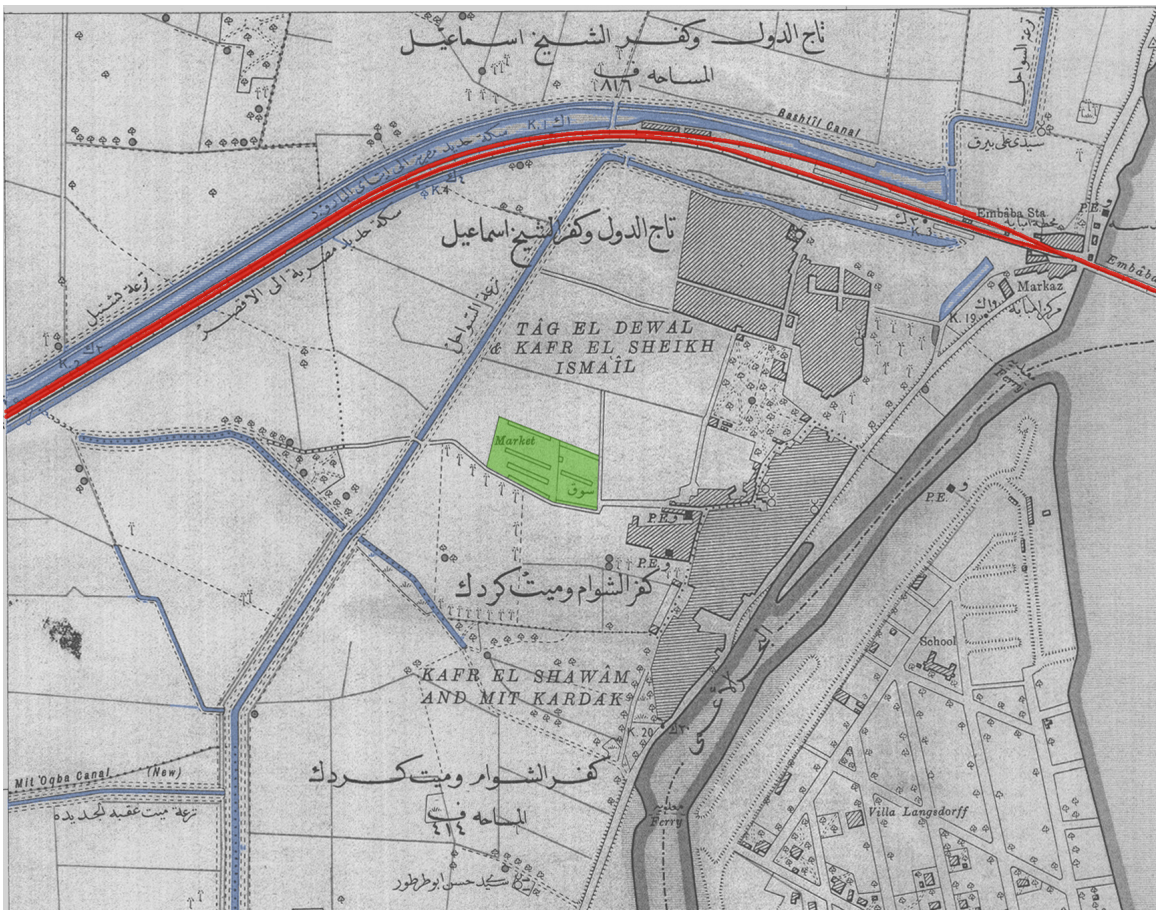

Figure 23. Railroad and Canals in 1911.

In 1892 the Imbaba rail bridge was completed (Abu-Lughod, 1971). The bridge over the Nile connected Egypt's three great rail lines, Cairo to Luxor, Cairo to Alexandria, and Cairo to Suez. The railroad is shown in red in figure 23. The new Imbaba rail station potentially connected the village to the rest of the country but did not give a convenient connection to the city just across the river. That there was a connection between Imbaba and Cairo is attested by the last addition to the 20th century village, the Imbaba market (shown in green in figure 23).

The size of the market seems excessive to serve the needs of the village itself but makes sense as a gathering point for the commodities of the west bank for shipment to the city of Cairo on the east bank (Abu-Lughod, 1971).

The next map in the series (figure 24) was made in 1918 at 1:5,000 scale, also by the Survey of Egypt. Overlaid in rose color is the extent of Imbaba village from 1911. In the seven years that separate these maps, though the world experienced the First World War in which Cairo was a major center of the British war effort, there have been almost no changes in Imbaba.

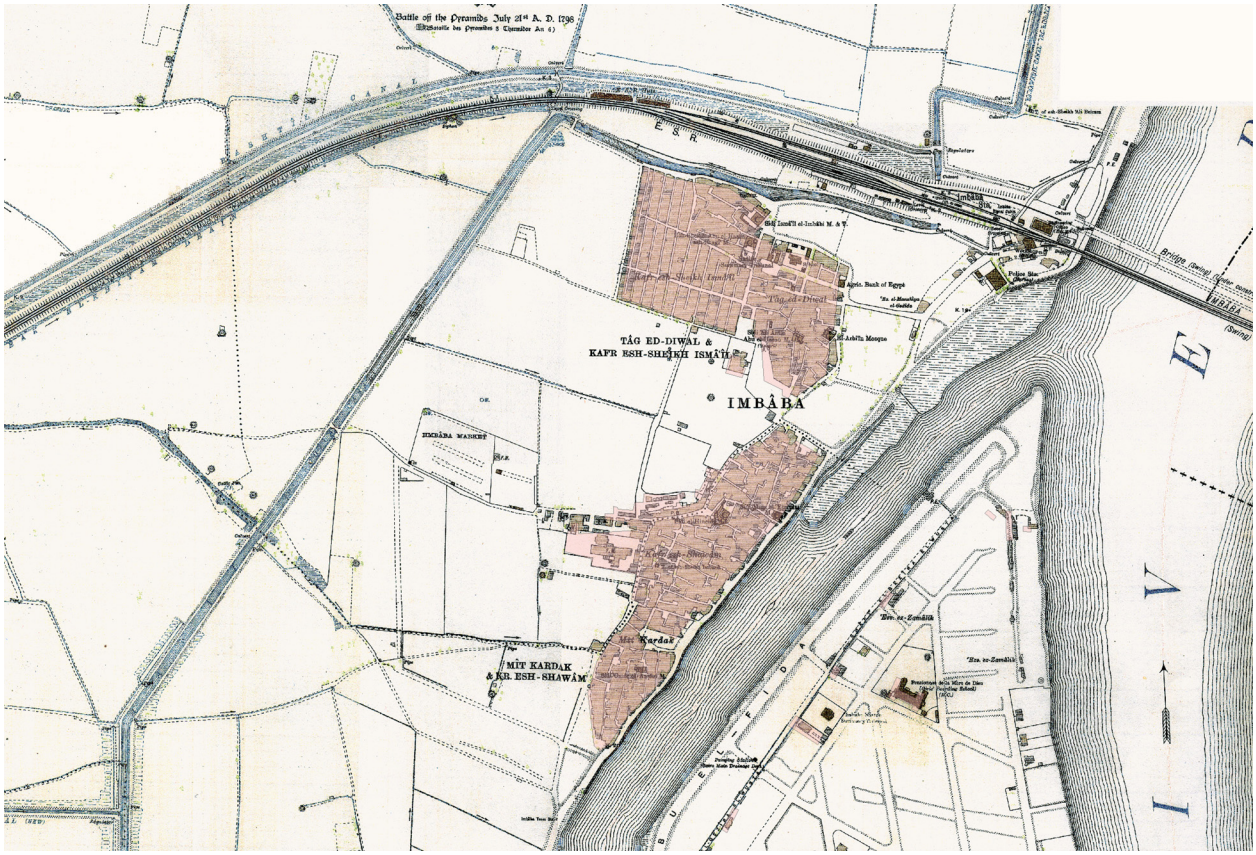

Figure 24. Imbaba 1918.

The larger scale of the 1918 map allows a closer view of the form of the agricultural village as it was in the first decades of the 1900s. In figure 25 we see the narrow winding streets and closed ally ways of a medieval Islamic city.

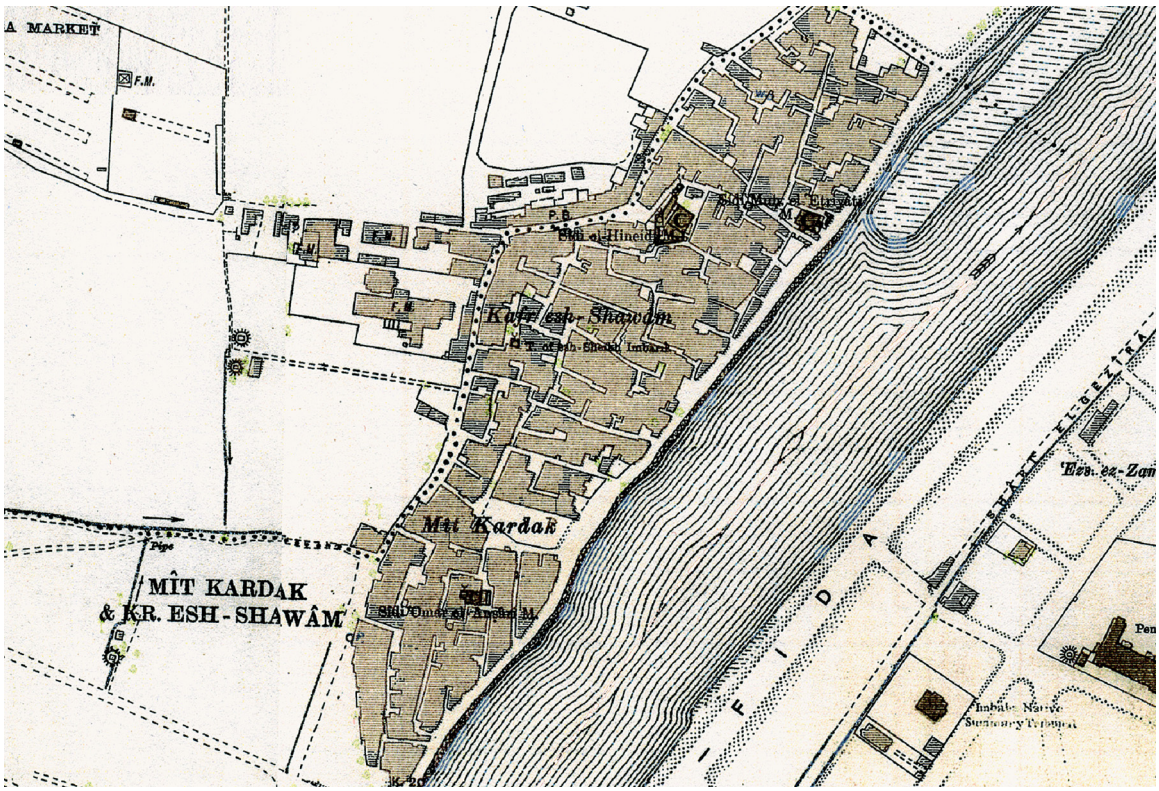

Figure 25. Shape of Imbaba village 1918.

The density of building and layout of the streets is virtually indistinguishable from the streets of Fustat, shown in figure 26 from a 1930s excavation, which follow the same pattern of densely built blocks with narrow winding streets.

The form of Imbaba village in theopening decades of the 20th century gives the impression of great antiquity but comparing the 1918 map to the village boundaries of 1800 suggests that much of the village in the 1900s had been constructed fairly recently. (Figure 27)

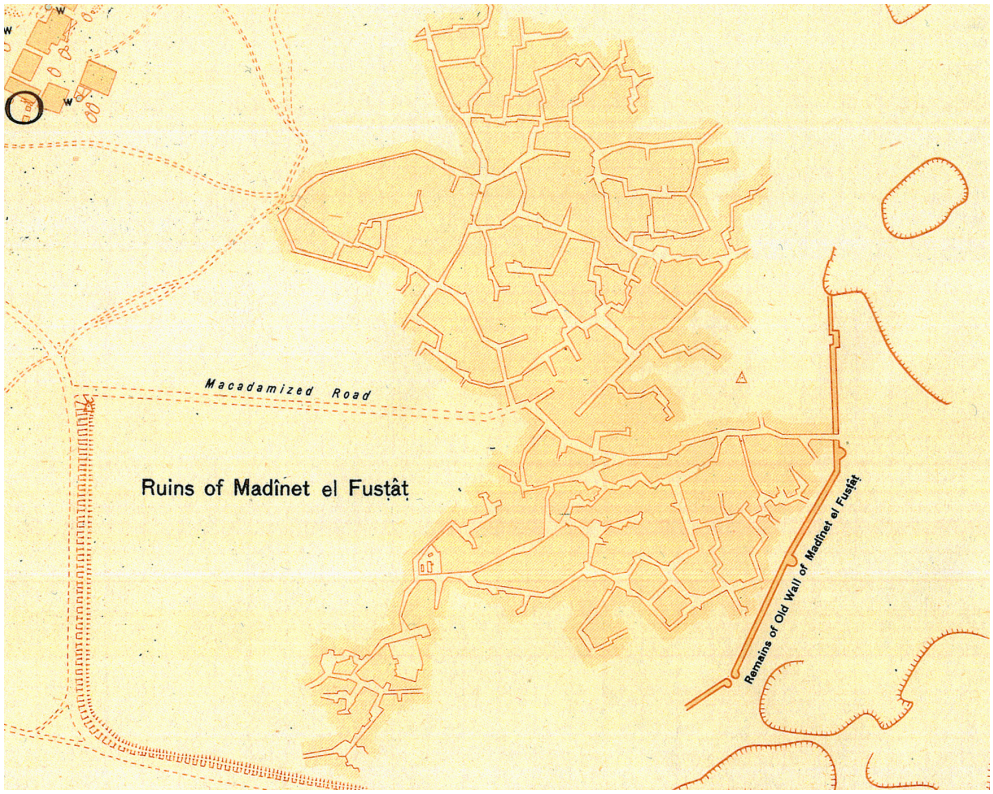

Figure 26. Excavation of Fustat 1930s.

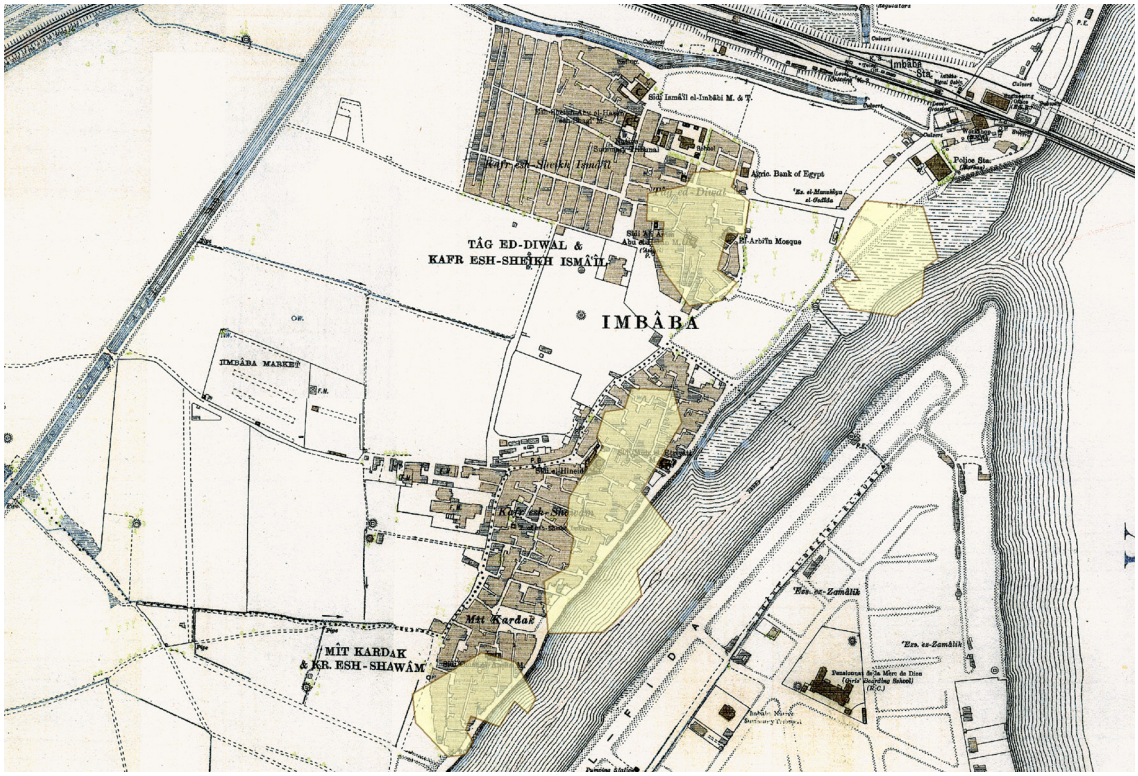

Figure 27. Extents of Imbaba village in 1800 overlaid on map from 1918.

The buildings themselves are probably not ancient but the building methods are. While these early 20th century maps show a continuity of building tradition with an earlier age they also show the beginnings of a break with that tradition. Figure 28 shows the northern part of Imbaba in 1918 overlaid with the modern shiyakhah boundaries. Parts of three shiyakhah divide the old village. The eastern portions, in Tag al-Duwal and Kafr al-Shaykh Ismail show a medieval pattern of development but the western part in present Gazirat Imbaba look strikingly different. The blocks are long and rectilinear. The streets are straight and run across multiple blocks. The layout resembles the divisions of the agricultural land in long narrow fields. In figure 29 the divisions of individual fields show up clearly in an aerial image from 2000 of an area south of Cairo, typical of agricultural land in the region. This represents the first development in Imbaba on land formerly used for agriculture.

Though there seems to be no change in Imbaba from 1911 to 1918 one major development has come to the qism that shows up on the maps. In 1913 a tramline was completed to Imbaba connecting the village to the rest of the city (Abu-Lughod, 1971). Figure 30 shows an overlay of the transit system of Cairo in 1918. Now that the agricultural land is free from flooding and the west bank is connected by a surface transportation link to Cairo proper, the stage is set to begin the development of Imbaba qism in earnest.

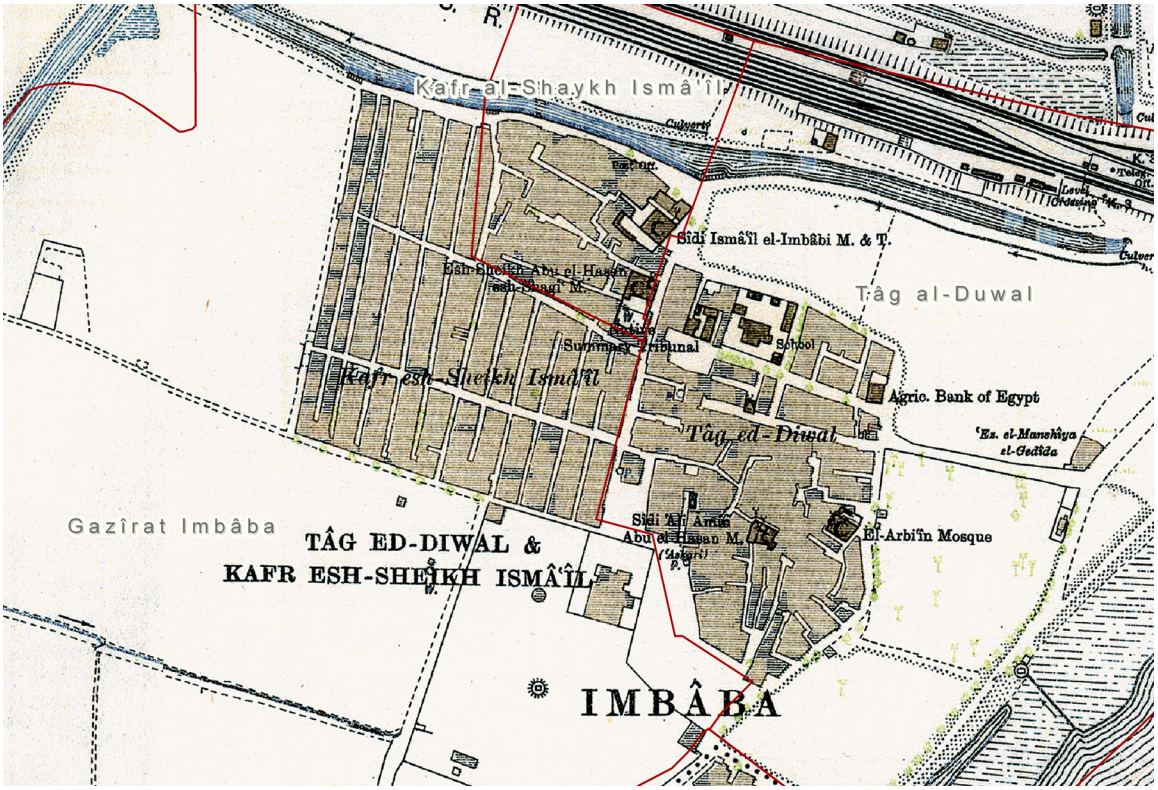

Figure 28. Changes in the layout of streets in Imbaba village 1918.

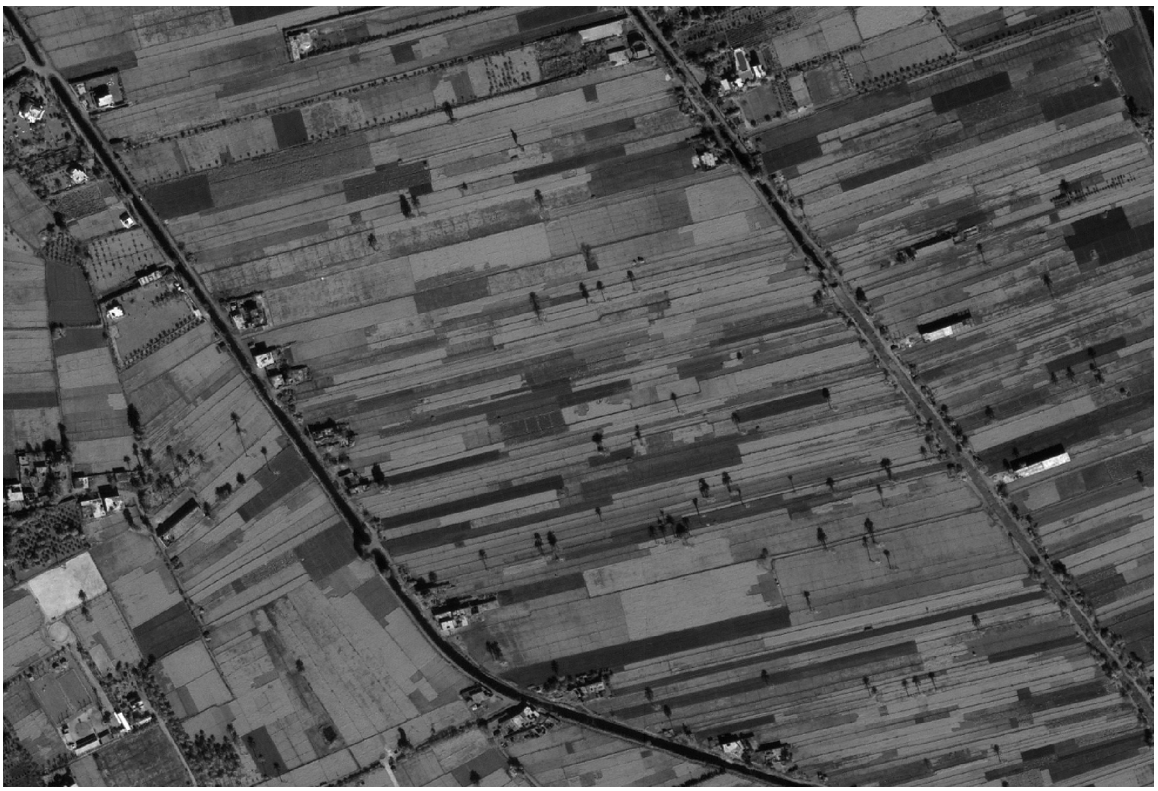

Figure 29. Ikonos satellite image of agricultural fields south of Cairo 2000.

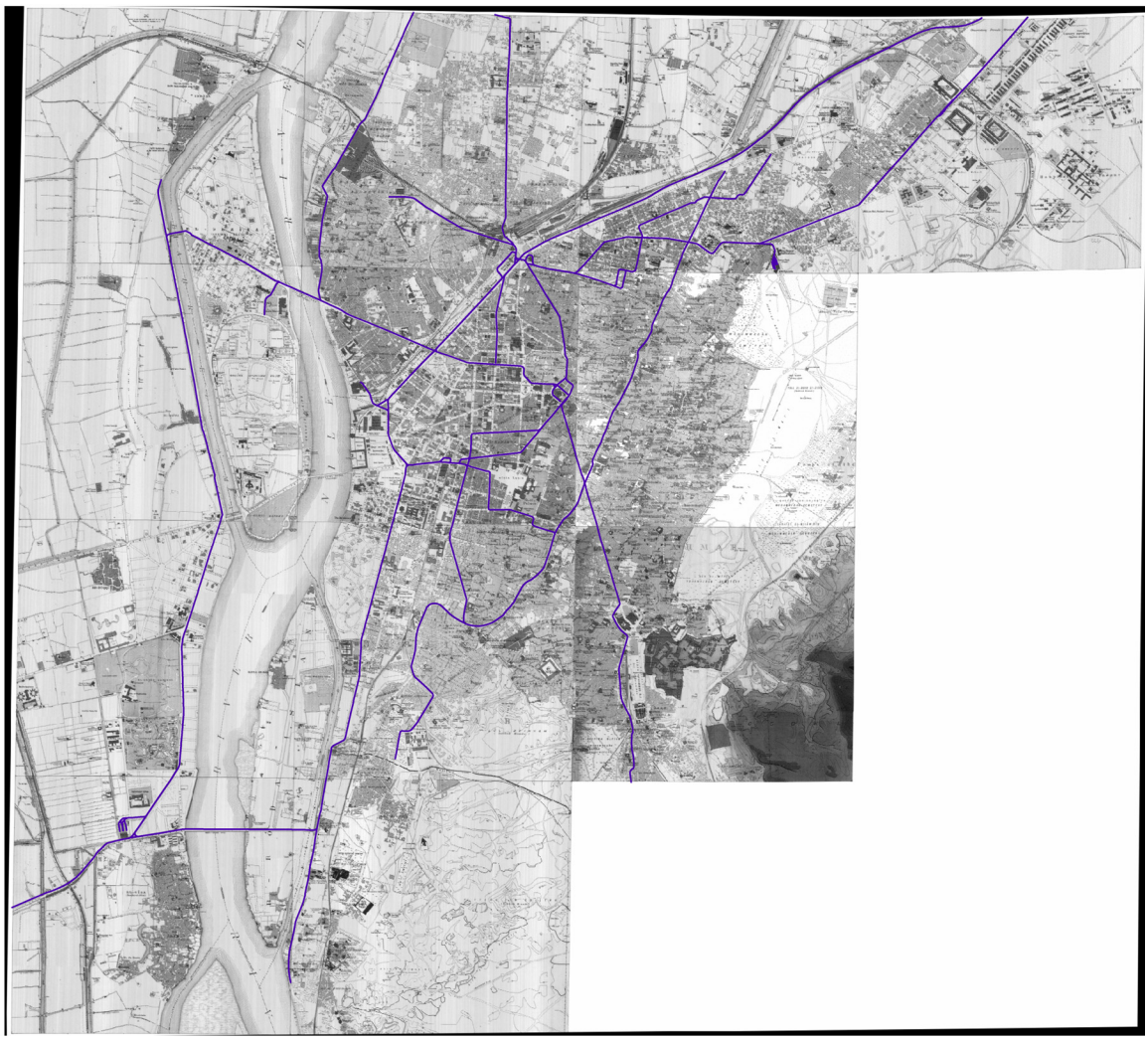

Figure 30. Cairo tram system in 1918. Imbaba is in the upper left portion of the map.

The next view of Imbaba comes from 1936, another map from the Survey of Egypt in 1:5000 scale. (Figure 31) New development can be seen in the southern end of Imbaba qism in proximity to the tram station. In Figure 32 the buildings existing in 1918 are overlaid on the map for 1936 to make the additions clearly visible.

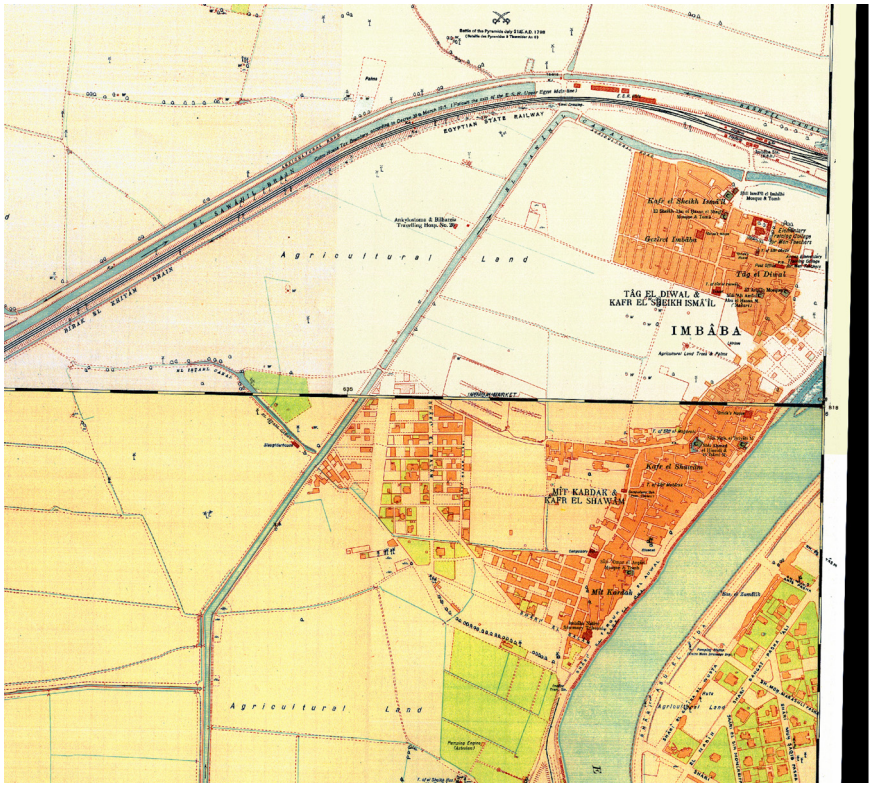

Figure 31. Imbaba village in 1936.

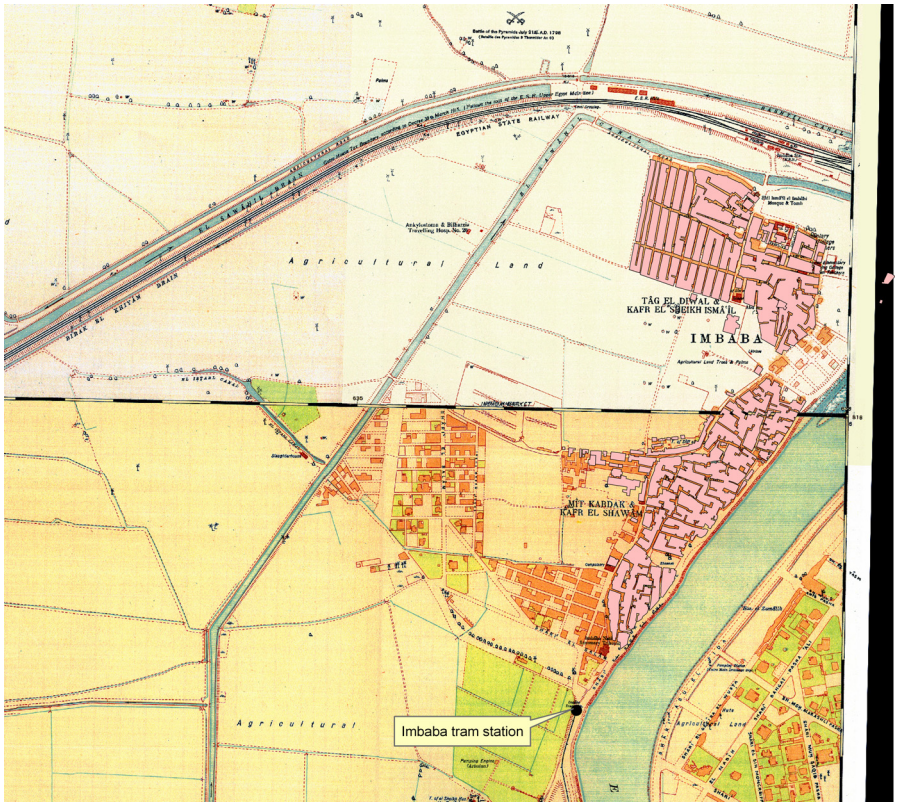

Figure 32. Extents of Imbaba village in 1918 overlaid on map from 1936.

The new development is in land that was formerly agricultural. The prior use has shaped the placement of structures, particularly the paths of principal roadways which follow the field boundaries and older pathways. (Compare Figures 33 and 34). However some roads, particularly cross streets, seem to have been laid out to a plan, superimposed on the older pattern.

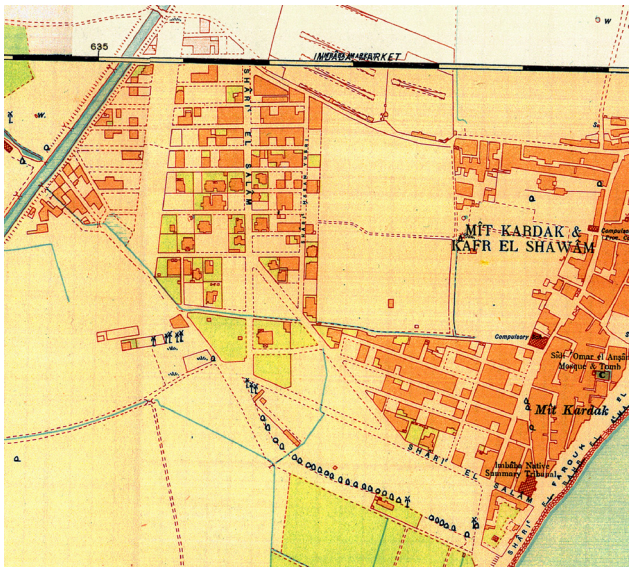

Figure 33. Imbaba village detail 1936.

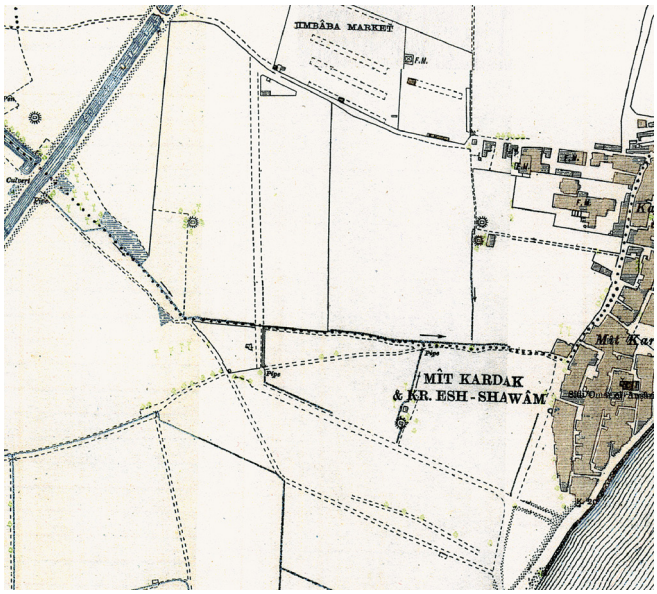

Figure 34. Imbaba village detail 1918.

The next image is 6 years later in 1942. The World is again at war and Cairo is a center for the British war effort against the Germans. This view of Imbaba is a product of that war, a German aerial reconnaissance photo. (Figure 35)

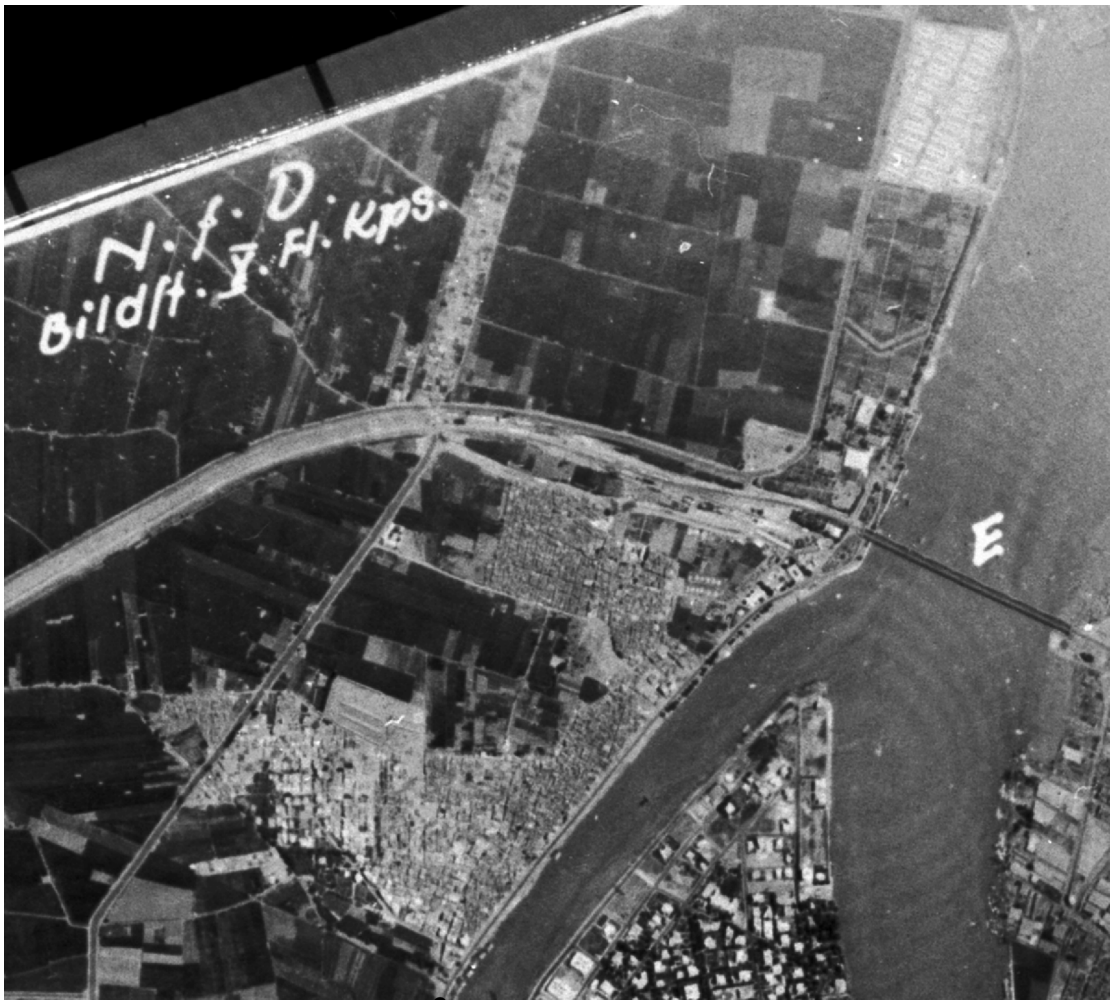

Figure 35. German reconnaissance photo from 1942 showing Imbaba.

Development continues in the southern part of Imbaba close by the tram station but there is also the beginning of development in the sections north of the main railroad line. Figure 36 shows a closer view of the developments in the south with the buildings from 1936 overlaid for contrast.

Figure 36. Extents of Imbaba village 1936 overlaid on photo from 1942 showing Imbaba market and tram station in green.

The area between the Imbaba market, outlined in green, and the tram station, shown as a green dot, is filling in. This suggests that much of the development is related to the trade in agricultural products moving through the market and onward to the city of Cairo by way of the tram or by boat across the Nile.

New construction in the north is shown in Figure 37. This is the first development unrelated to the old agricultural village and marks the beginnings of the modern evolution of Imbaba.

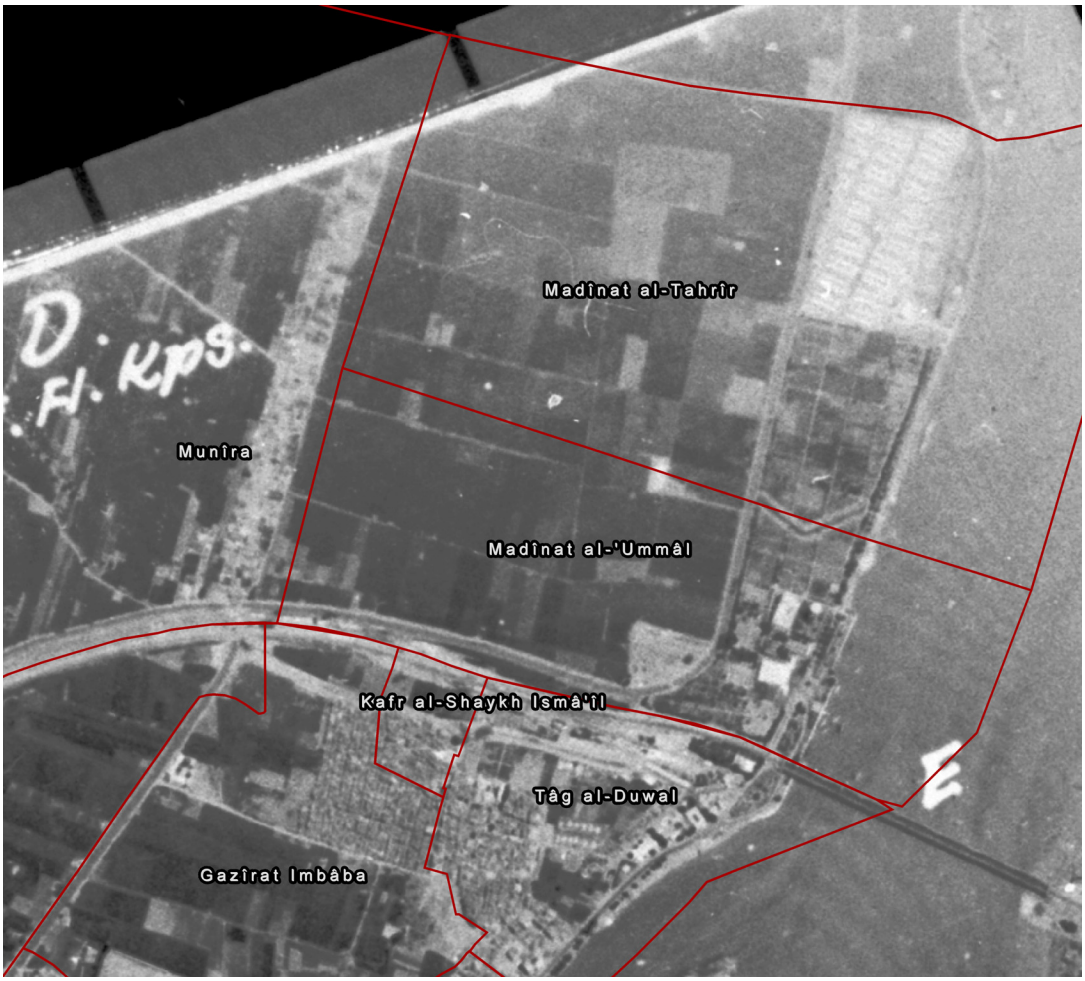

Figure 37. Madinat al-Tahrir and Madinat al-Ummal Qism in 1942.

In the northeast corner of Madinat al-Tahrir a large hospital has been built. The buildings are faintly visible in the photo but by comparing this area to the same region in the 1977 map the use becomes clear. (Figures 38 and 39) The hospital is separated from Cairo by the river so it was most likely intended for British wounded from the fighting in Libya.

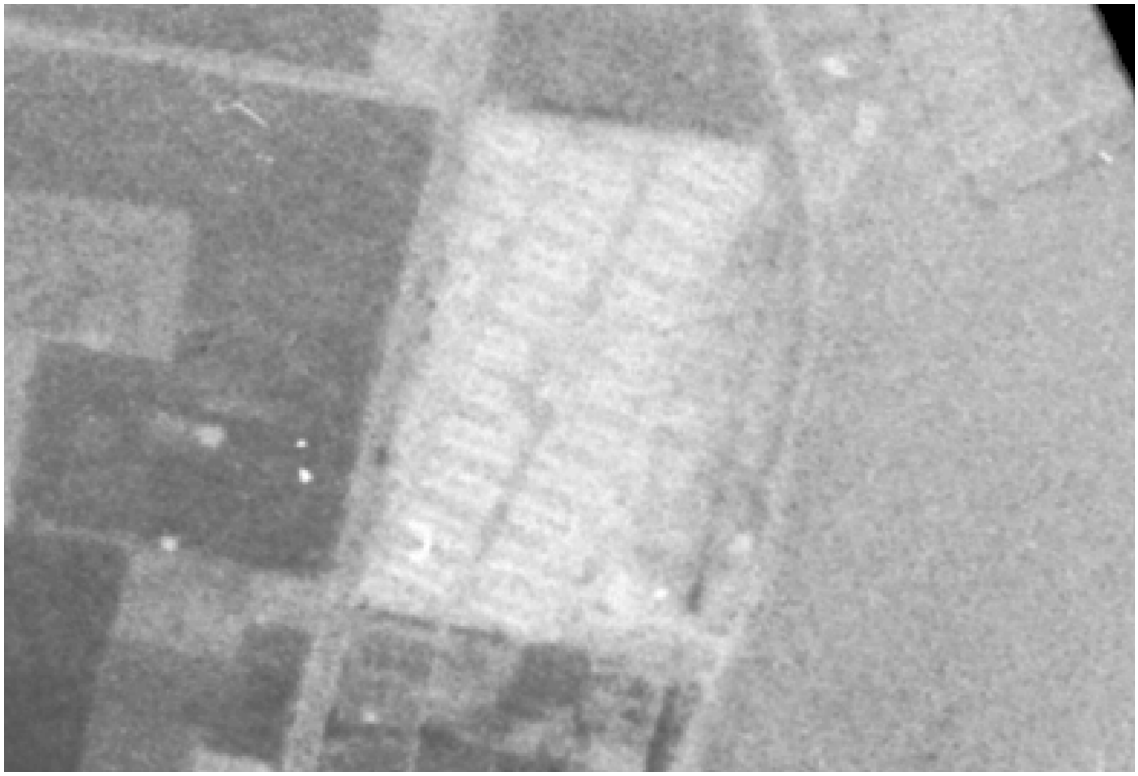

Figure 38. Detail of hospital in 1942.

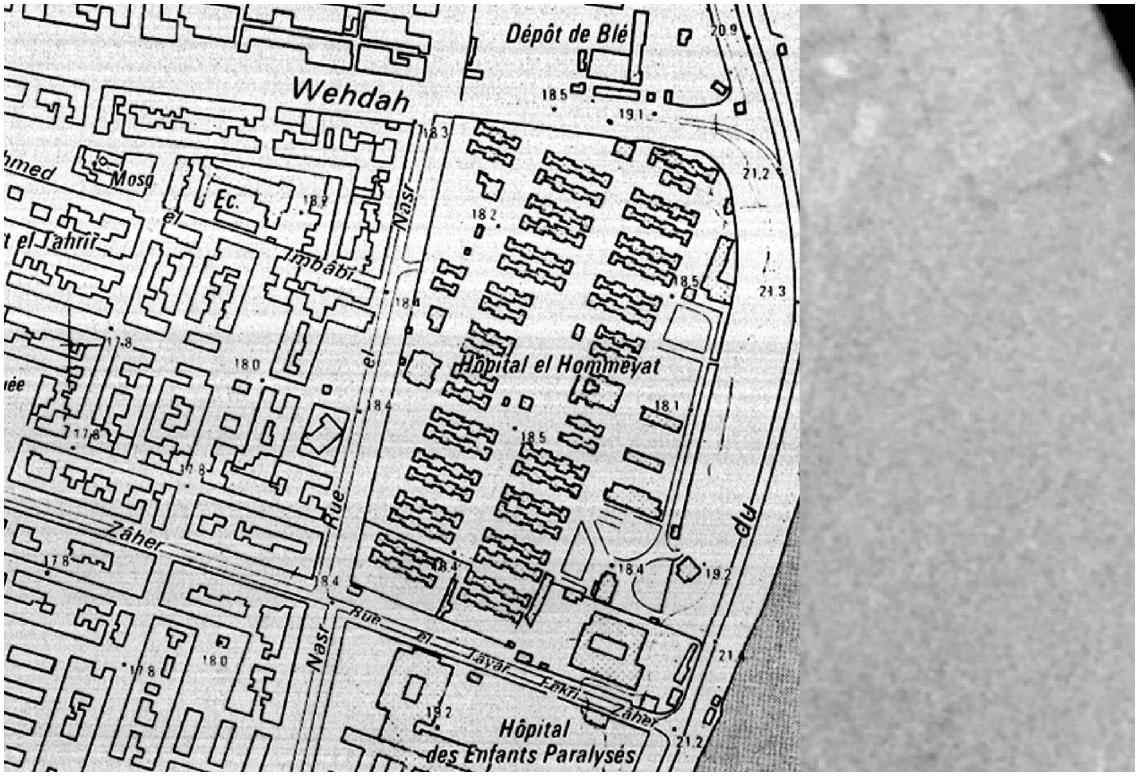

Figure 39. Map of same hospital 1977.

More difficult to explain is the strip of new development running north from the railroad along the border of Munira shiyakhat. Figure 40.

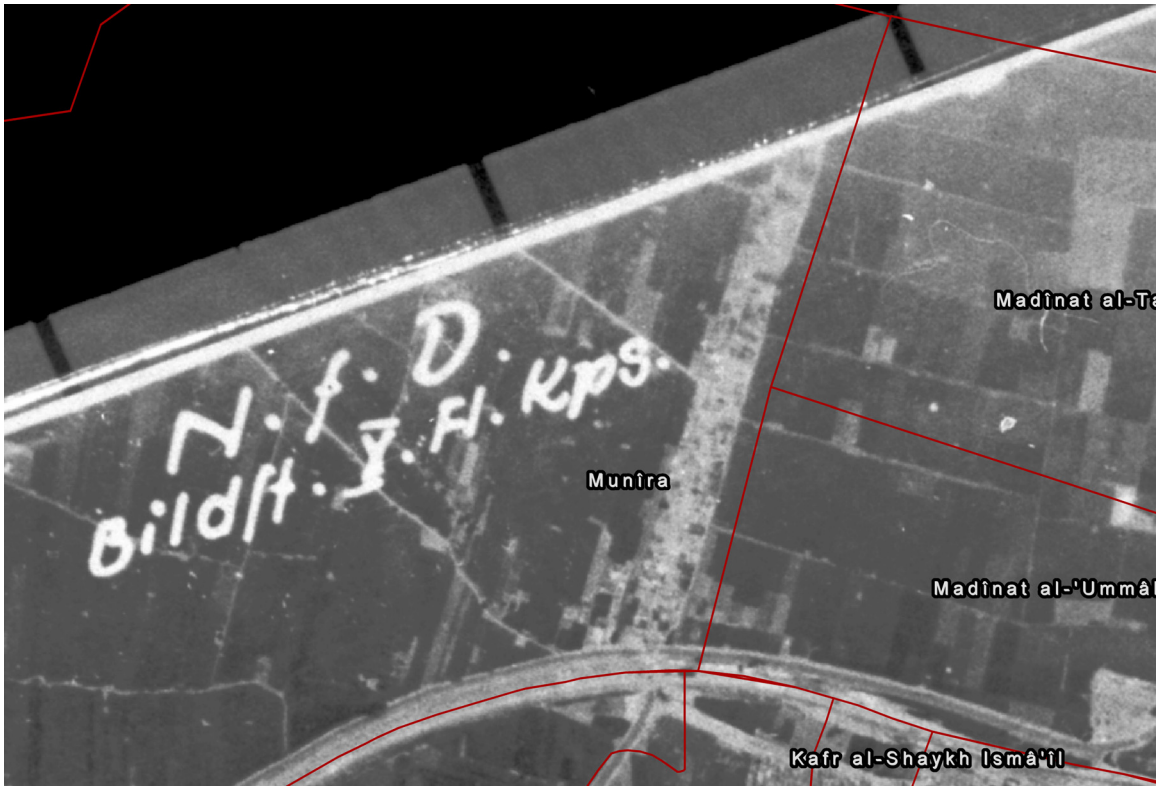

Figure 40. Informal development in Imbaba 1942.

It is separated from the old village by the barriers of the main railway line and a major irrigation canal making this an unlikely area for development. A close view of the 1936 map shows that at the southern end of the built strip is a bridge over the canal and a grade level crossing of the railroad line. (Figure 41) Given the subsequent history of Munira as a major informal settlement, this connection seems to be the seed that gives rise to the first informal development in Imbaba.

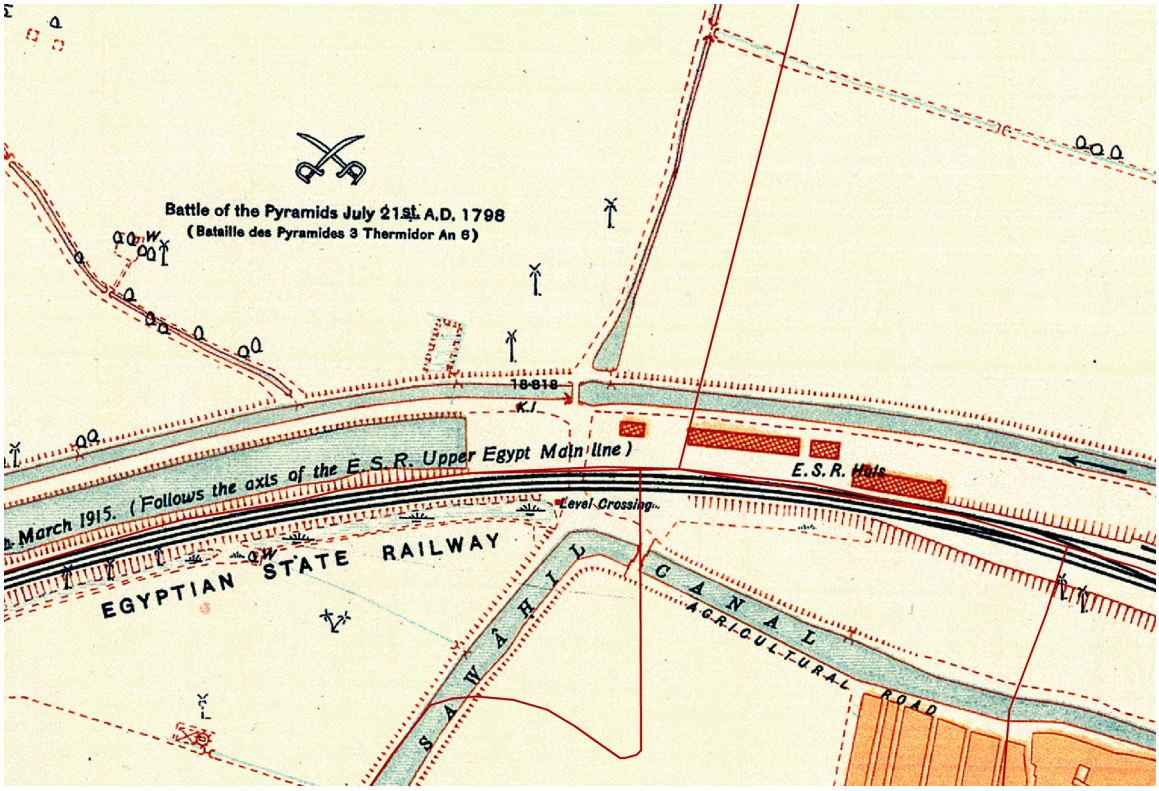

Figure 41. Railroad and canal crossings 1936.

The Post War formal developments:

The next data set dates from 1962. The twenty years that intervened were tumultuous in the history of Egypt. World War Two was followed by the first Arab-Israeli war in 1948. Egypt's defeat in that war contributed to the 1952 revolution, which brought to power Gamal Abdel Nasser

In Figure 42 we see Imbaba from a Corona satellite image from 1962. Corona was the first operational reconnaissance satellite. This image is from one of the early successful missions and is of fairly low resolution but it is possible to make out significant changes since the 1940s.

Figure 42. Corona Satellite image of Imbaba 1962.

In Figure 43 the built area of 1941 is overlaid on the 1962 image. The most striking changes are in the Madinat al-Tahrir and Madinat al-Ummal shiyakhah. There is also significant building in the Munira shiyakhat and the first major building in Abd al-Naim shiyakhat.

In Figure 44 Madinat al-Tahrir and Madinat al-Ummal are completely built up but it is difficult to see any detail of the buildings.

Figure 43. Extents of Imbaba development in 1942 over laid on Corona image 1962.

Figure 44. Madinat al-Tahrir and Madinat el-Ummal in 1962.

Figure 45 shows the same area from a higher resolution image made in 1966. In this image areas of different uses are highlighted based on the 1977 map shown earlier. In addition to the hospital built before 1942, shown in green, three more hospitals have been added. Other institutional buildings have been built in the strip overlooking the Nile and apartment blocks have been laid out surrounding schools, in lavender, filling the remainder of the land.

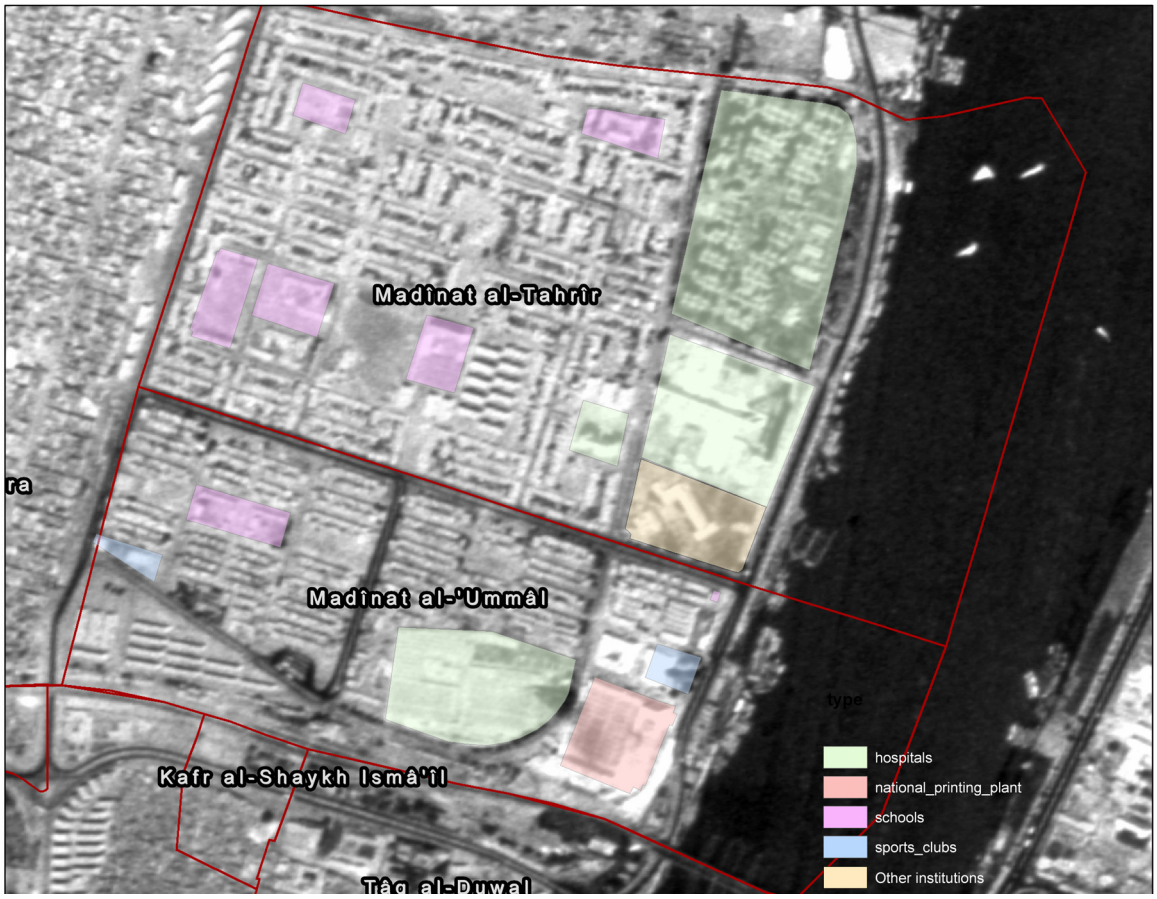

Figure 45. Madinat al-Tahrir and Madinat al-Ummal overlaid with non-residential land uses, 1968.

This development is qualitatively different from the building that has preceded it in Imbaba. The buildings are large, more formally arranged, and are uniform in footprint and probably in style of construction. Volait identifies these developments as planned by the Tanzim

department. Started in 1947 the construction was interrupted in 1952 and then completed in 1954 (Nielsen, 2001).

Figure 46 shows significant additions to Munira shiyakhat. In contrast this development consists of small buildings, densely packed, and following the layout of the preexisting agricultural land use rather than a formal plan.

Figure 46. Informal development areas in 1942 overlaid on Corona image from 1962.

In the Abd al-Naim shiyakhat a group of buildings have been built that appear to be an industrial use, shown circled in red in Figure 47.

Figure 47. Industrial land use circled in red on Corona image from 1962.

The appearance of this factory signals another great change in Imbaba since the 1940s. As the land use transformed from agricultural to urban the system of canals that supplied irrigation water became superfluous just as the need for transportation of people and goods became acute. Four major canals were covered over and converted to roadways in Imbaba by the 1960s. Figures 48 and 49 show the change in a section of canal from 1936 to 1966. This road now provides access to the new industrial land uses.

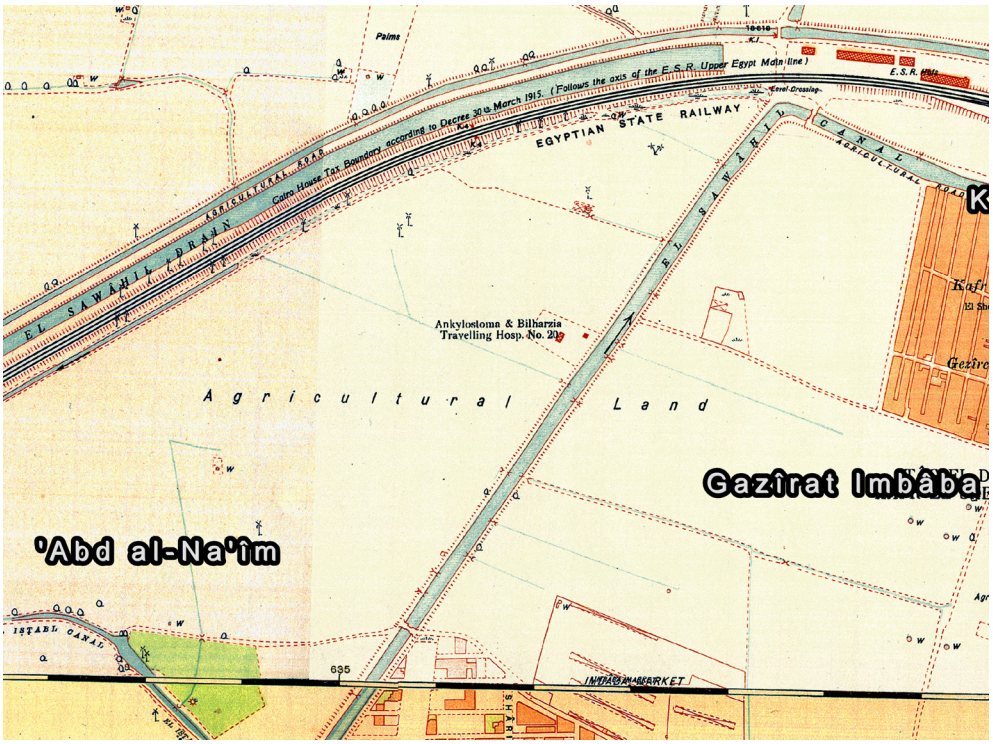

Figure 48. Agricultural land in Imbaba in 1936.

Figure 49. Area from Figure 47 converted to urban land use shown in Corona image, 1966.

Figure 50 shows in blue lines the major irrigation canals that have been converted to roads by 1966 forming the backbone of Imbaba's transportation grid.

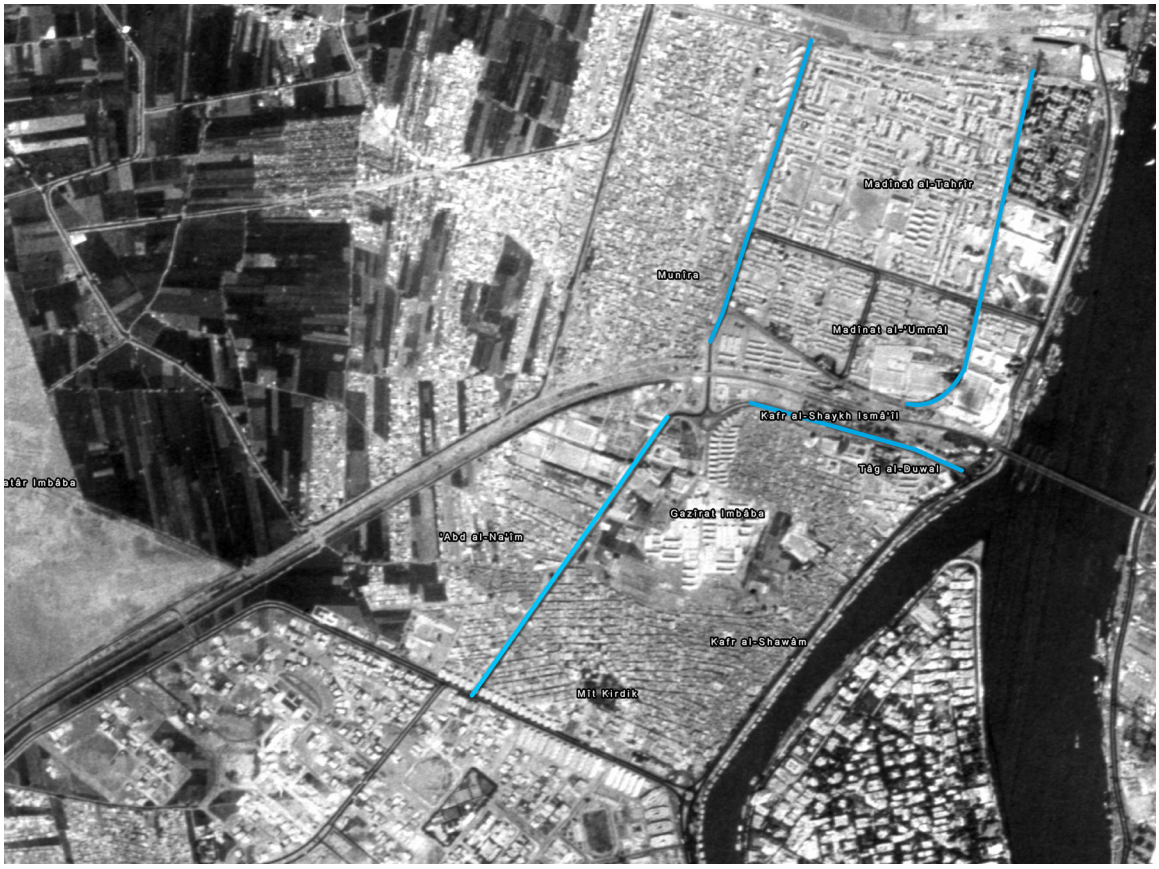

Figure 50. Canals converted to transportation in Imbaba by 1966.

The last shiyakhat to show major change in the 1962 image is Matar Imbaba in the extreme western end of the qism. Contrasting Figures 51 and 52 a large feature has replaced the agricultural fields. The nature of the change is more apparent in Figure 53 from 1968. A landing strip is visible in the large cleared area and a group of buildings in the southwest corner seem to be associated with the strip. This is likely to be a military airfield but can't be positively identified.

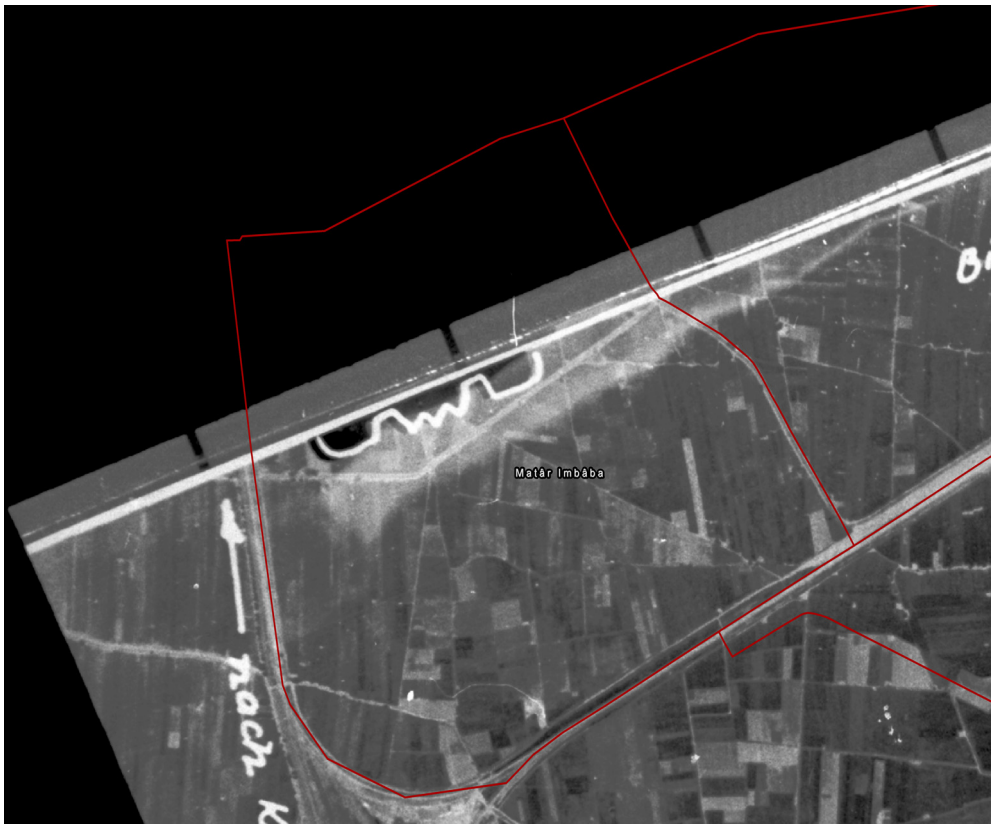

Figure 51. Matar Imbaba qism in 1942.

Figure 52. Airfield in Matar Imbaba, 1962.

Figure 53. Airfield in 1968.

This airfield formed a barrier to the westward growth of the informal settlement in Munira. It also affects the measurements of population density in Matar Imbaba.

The next image in the series is from the KH-8 spy satellite made in 1966 (Figure 54). The previous step moved forward in time 20 years this step moves only four years. While the time interval is short there are still noticeable changes in Imbaba. Figure 55 shows the developed area of 1962 overlaid on the 1966 image.

Figure 54. KH-8 satellite image of Imbaba from 1966.

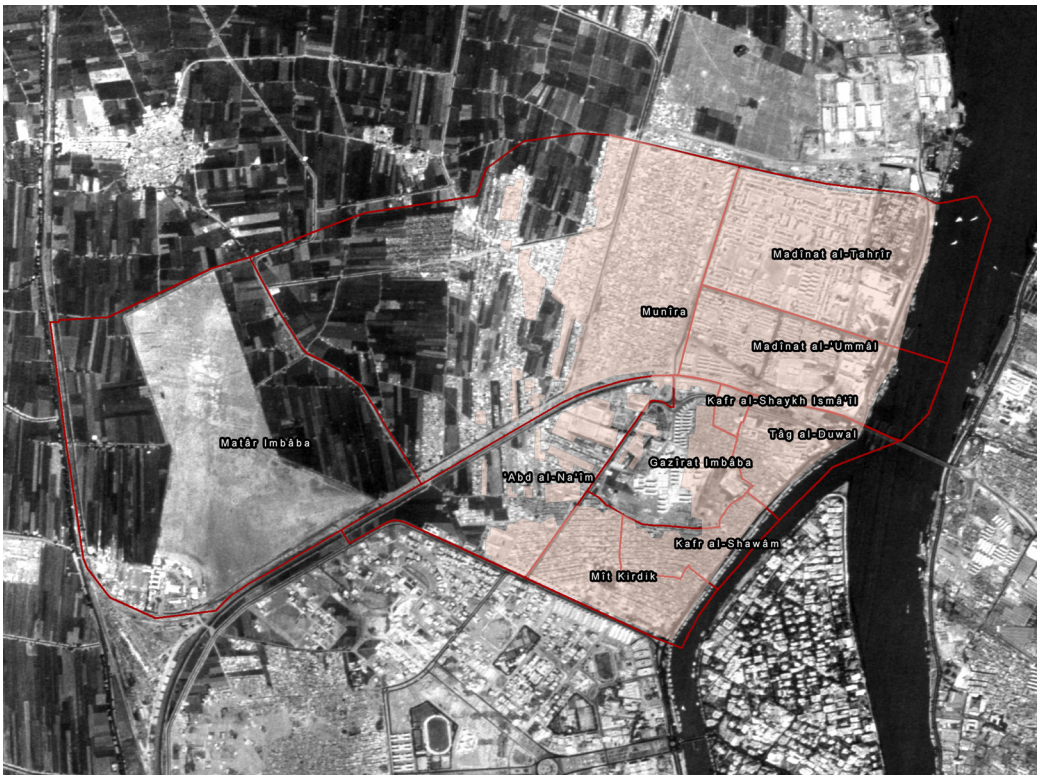

Figure 55. Extent of development from 1962 overlaid on image from 1966.

The most notable new development is in Gazirat Imbaba shiyakhat. In Figure 56 new tower blocks are visible.

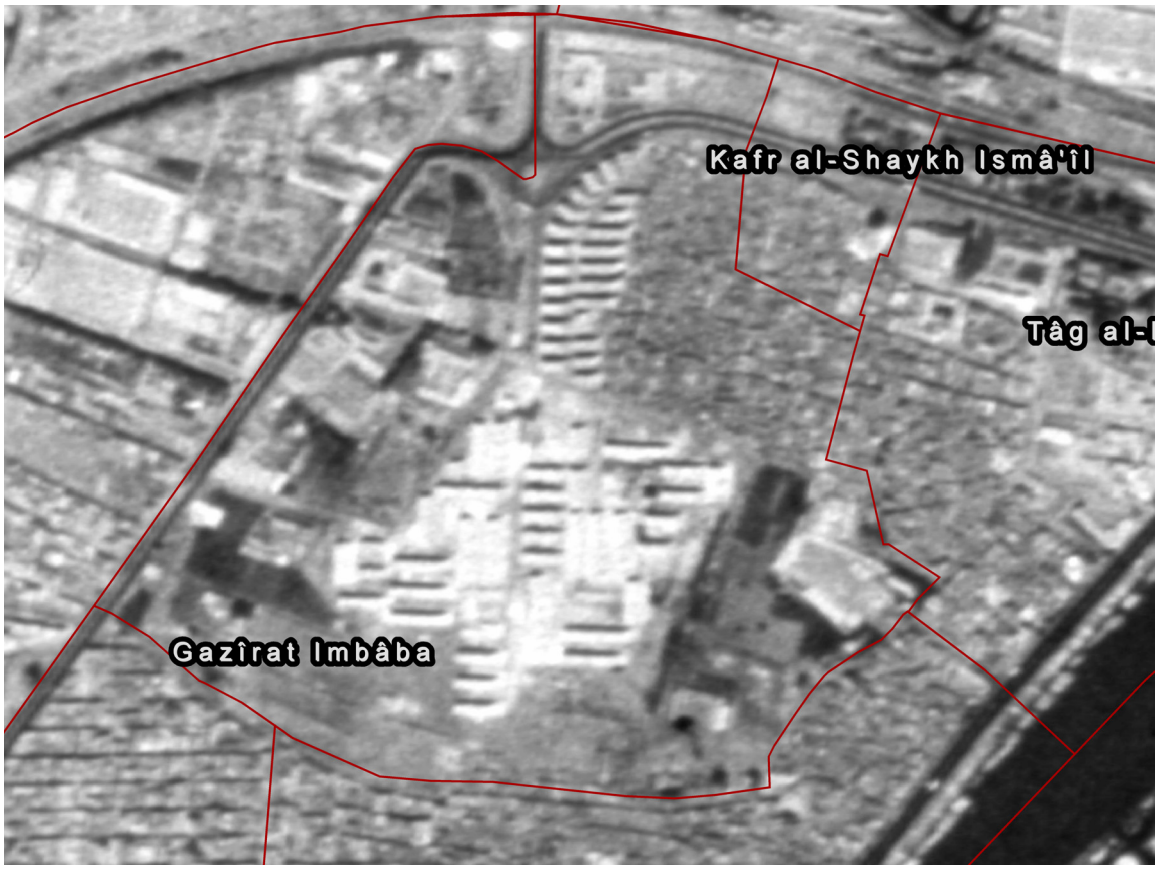

Figure 56. Tower block development in Gazirat Imbaba qism, 1966.

Egypt in the 1960s had close ties with the Soviet Union and these tower blocks, which began to dot the Cairo landscape in the post revolutionary period, are closely associated with Soviet influence. This type of housing development traces its roots to Le Corbusier and the Modernist movement in architecture and similar developments were built in France, Germany and particularly the United States at about the same time.

Intended to house the poor and working class their inadequacy to the task is attested by the continued expansion of the informal settlements elsewhere in Imbaba.

In the Abd al-Naim shiyakhat new growth is seen south of the industrial buildings noted in the 1962 image, shown in Figure 57.

Figure 57. Development in Abd al-Naim qism in 1962 overlaid on image from 1966.

North of the railroad lines in Munira shiyakhat building has continued in the agricultural land (Figure 58).

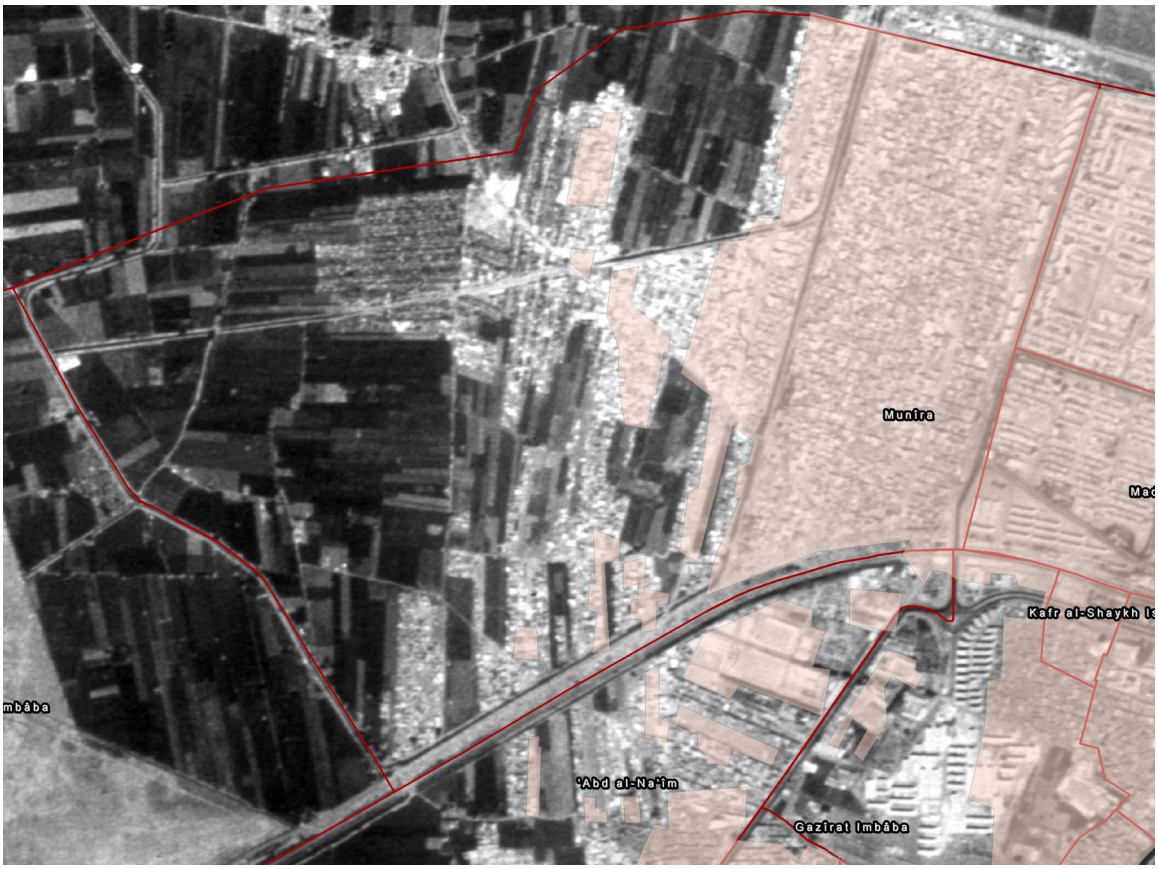

Figure 58. New development in Munira qism in 1966.

In the higher resolution image it is notable that development follows the boundaries of the farm fields. One field will be completely developed and the neighboring field remains untouched. The contrast to the formal layout of the tower blocks noted earlier is striking. In the case of the formal development the form of previous land use is masked by the overlying use. In the informal developments the shape of the previous land use is preserved in the orientation of streets and the blocking of the buildings.

The next snapshot of development in Imbaba is from a Corona spy satellite in 1968 shown in Figure 59.

Figure 59. Corona satellite image of Imbaba from 1968.

Egypt had just fought the Six Day War with Israel which helps to account for the intense interest of the CIA in collecting imagery of Cairo. Only two years have passed since the previous image was made and little has changed in Imbaba. Figure 60 shows the built extant of 1966 over the 1968 image.

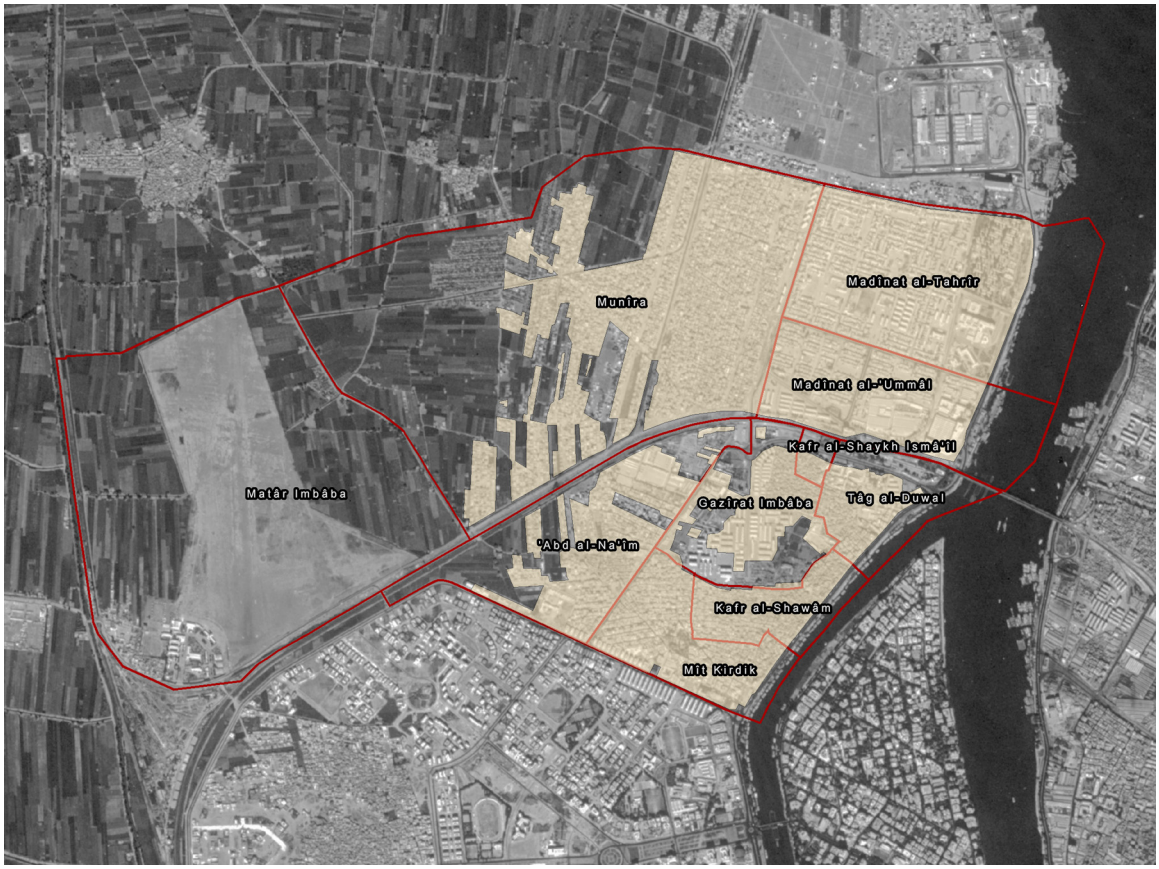

Figure 60. Extent of development in Imbaba from 1966 overlaid on image from 1968.

The only major change is in the Gazirat Imbaba where new tower blocks have been added to the previous development. Figure 61 shows the buildings in detail. The location of the building is interesting because it is the site of the former Imbaba market. The transformation of Imbaba from agriculture to urban has supplanted the need for a market with the need for housing.

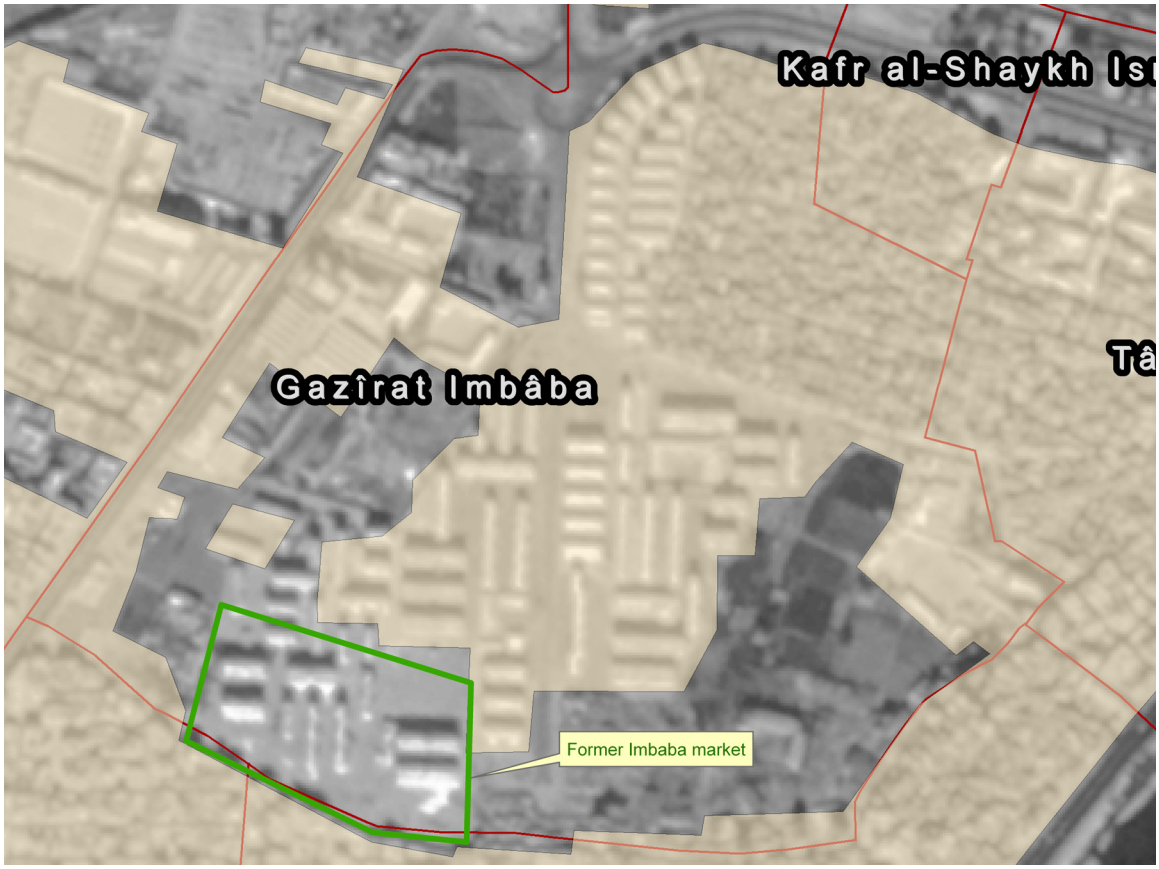

Figure 61. Development in Gazirat Imbaba from 1966 to 1968.

A map rather than an aerial image represents the next step in the timeline of development. This map, shown in figure 62, is one sheet of a series produced in 1977 for the Egyptian government by a French company showing the city at a scale of 1:5000. This is nine years after the last view of Imbaba and Egypt has been on a war footing for much of that time. Egypt's defeat in 1967 by the Israeli army led to a period of open hostility that eventually erupted into war again in 1973. In spite of the country being on a war footing, development has continued in Imbaba.

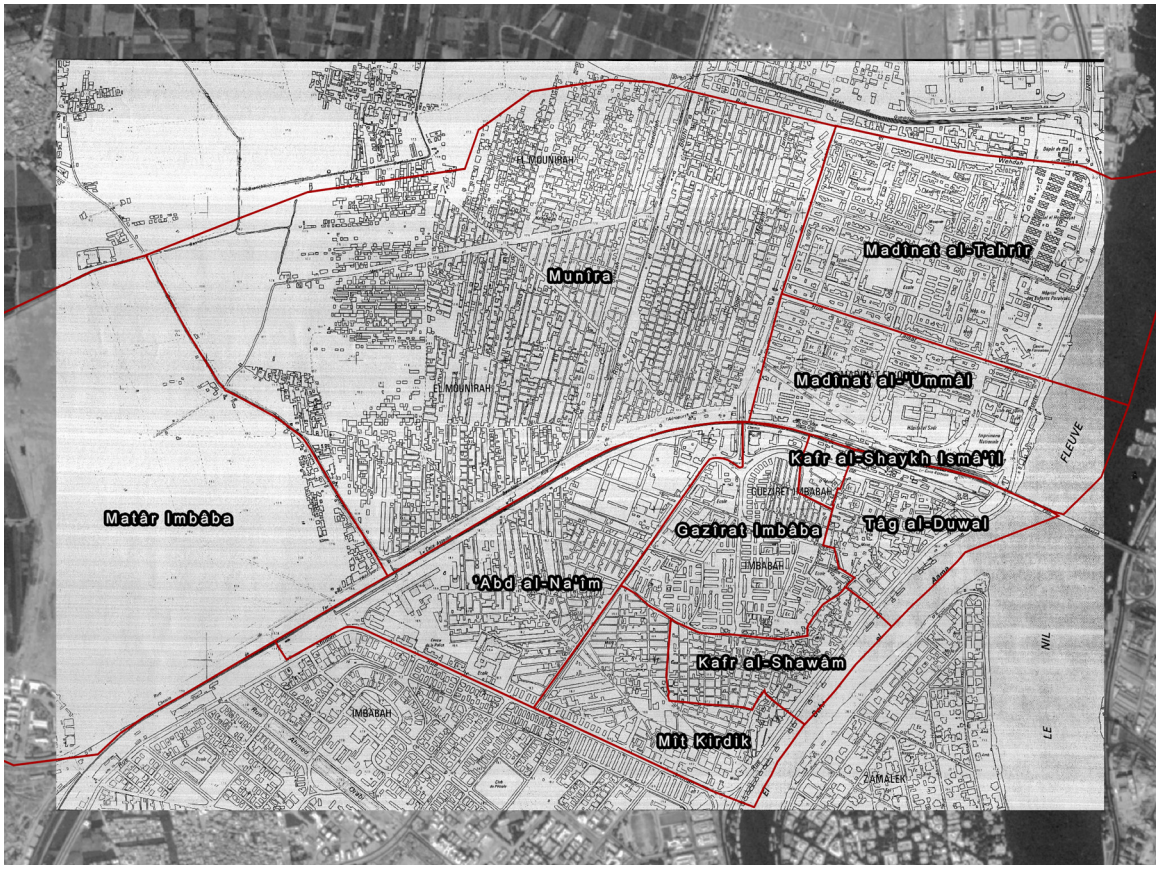

Figure 62. Imbaba in 1977.

In Figure 63 the previously developed areas are again shown as an over lay on the current view. The eastern shiyakhah have now been completely developed. What empty land remained has now been infilled. In Gazirat Imbaba more tower blocks have been added making that the dominant land use in that shiyakhat as shown in figure 64.

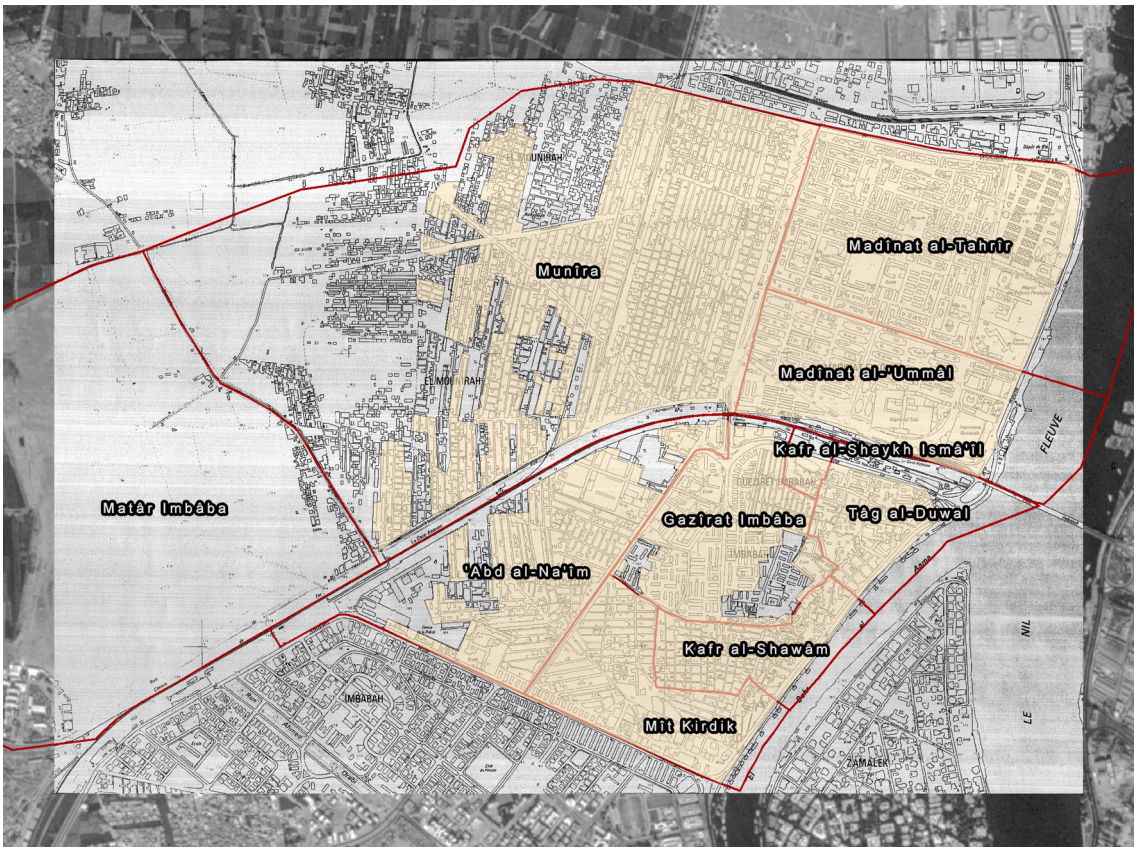

Figure 63. Development in Imbaba from 1968 overlaid on 1977 map.

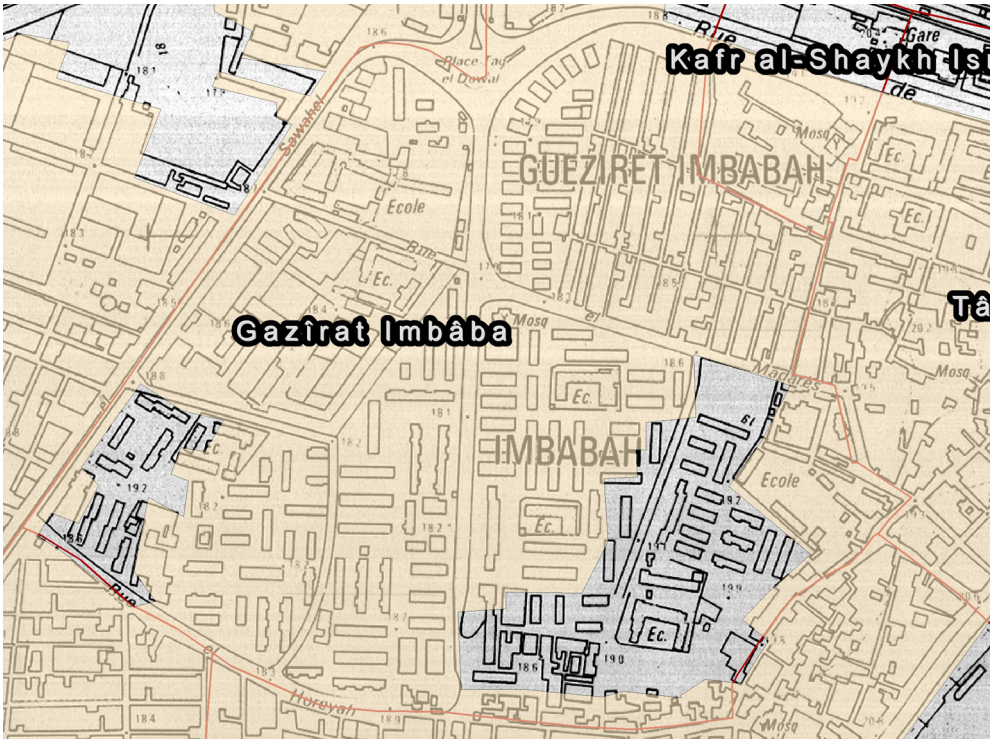

Figure 64. Detail of Gazirat Imbaba in 1977.

In Abd al Naim there seems to be the addition of another industrial facility, shown circled in red in Figure 65 and again in a very high resolution Ikonos image from 2000 in Figure 66.

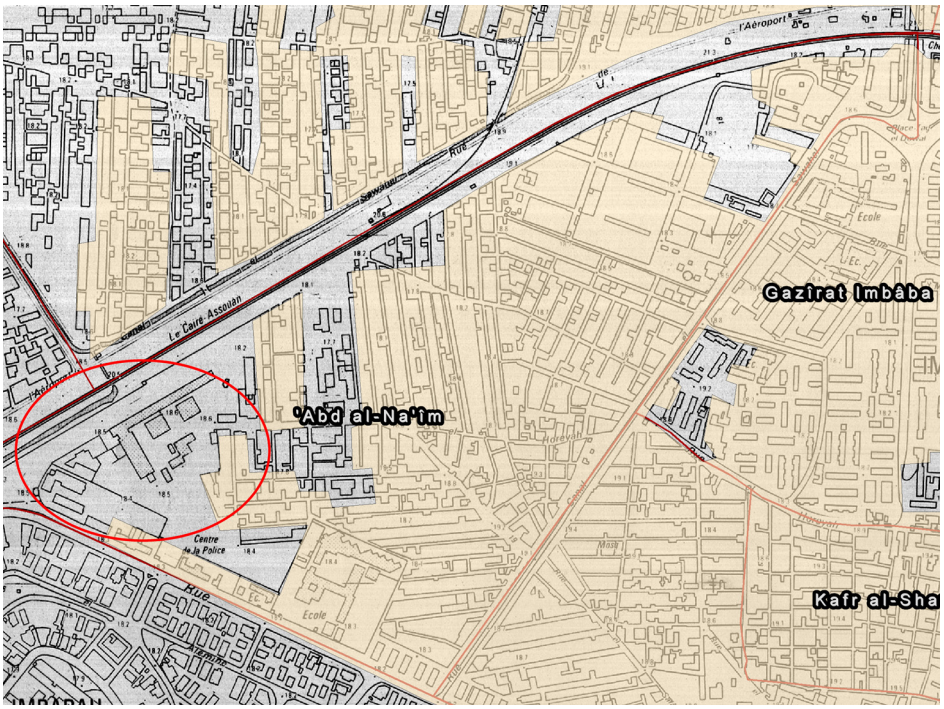

Figure 65. New industrial development in Imbaba, 1977.

Figure 66. Ikonos satellite image of industrial buildings, 2000.

Infitah Period:

In Munira shiyakhat, where there remained significant agricultural uses in 1968, the conversion to urban use continued. In Figure 67 the newly built sections are shown. Though the field boundaries are not visible in the map, as they have been in the aerial imagery, the pattern of building in discrete plots still shows up in the almost dendritic pattern of the advancing interface between built up and agricultural land.

Figure 67. New development in Munira qism, 1977.

The next time slice in this study is a Landsat satellite image from 1986. Compared to the images used up to this point Landsat's spatial resolution is very coarse at 30 meters per pixel. The multispectral capability of Landsat shows properties of the

land uses by other means than the photo interpretation methods used so far. In Figure 68 Imbaba is shown in a traditional false color palette. Band four of the image representing near infrared wavelength is shown as red. Band three, red wavelength, is shown as green and band two, green wavelength, is shown as blue. Vegetation appears as red in the image due to its high reflectance of infrared light. Figure 68 shows that Munira has lost almost all of its agricultural land and the growth of settlement has moved into neighboring Matar Imbaba.

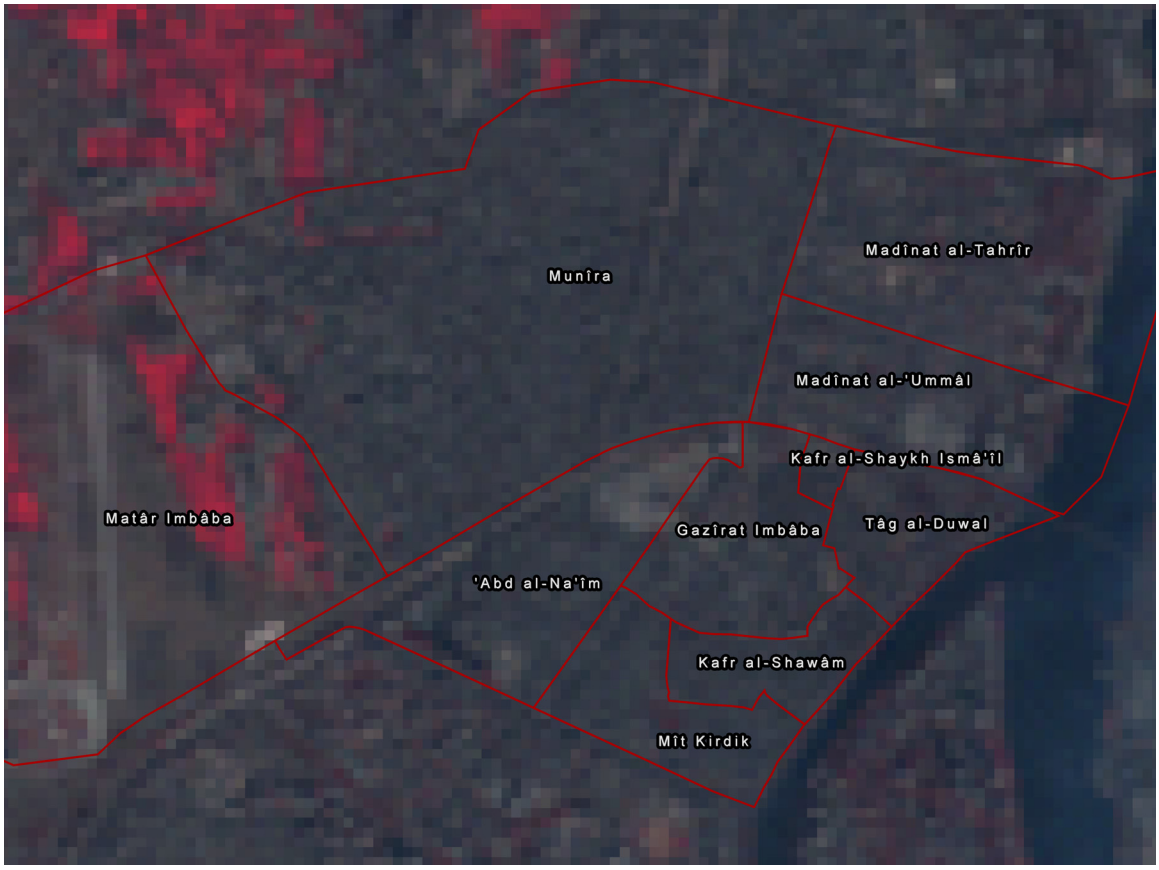

Figure 68. Landsat image of Imbaba 1986.

Overlaying the 1977 developed areas on the 1986 image in Figure 69 gives an indication of the changes.

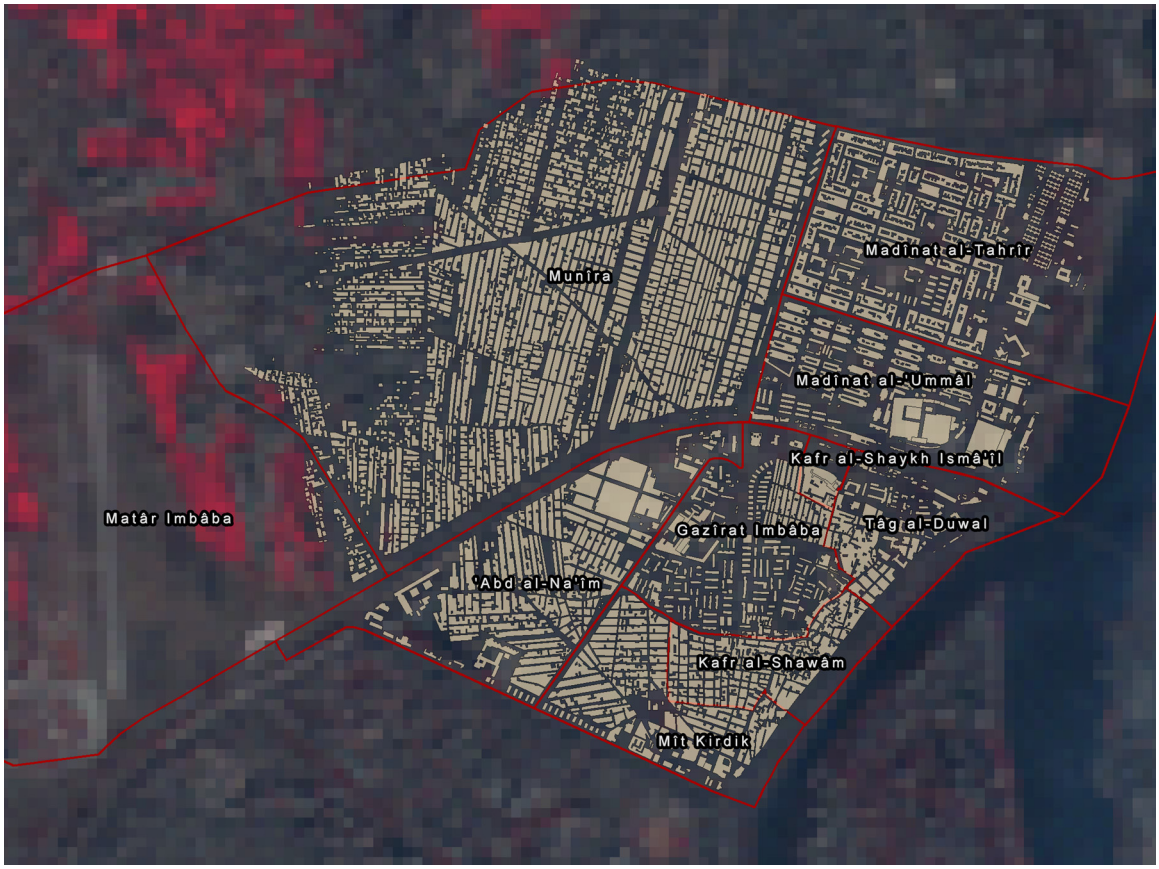

Figure 69. Developed areas from 1977 overlaid on 1986 Landsat.

Landsat's multispectral range also allows techniques such as spectral classification to be used on this image. Figure 70 displays the results of an unsupervised classification of 15 classes done in ERDAS Imagine. In this image there are four classes that, when compared to the other images in this study, seem to represent undeveloped land, including parts of the airbase not used as the landing strip. Subtracting these classes gives a vector file representing the developed areas in 1986. This is shown in Figure 71

over laid on the final temporal snapshot in the study an image from 1999 by the Indian remote sensing satellite.

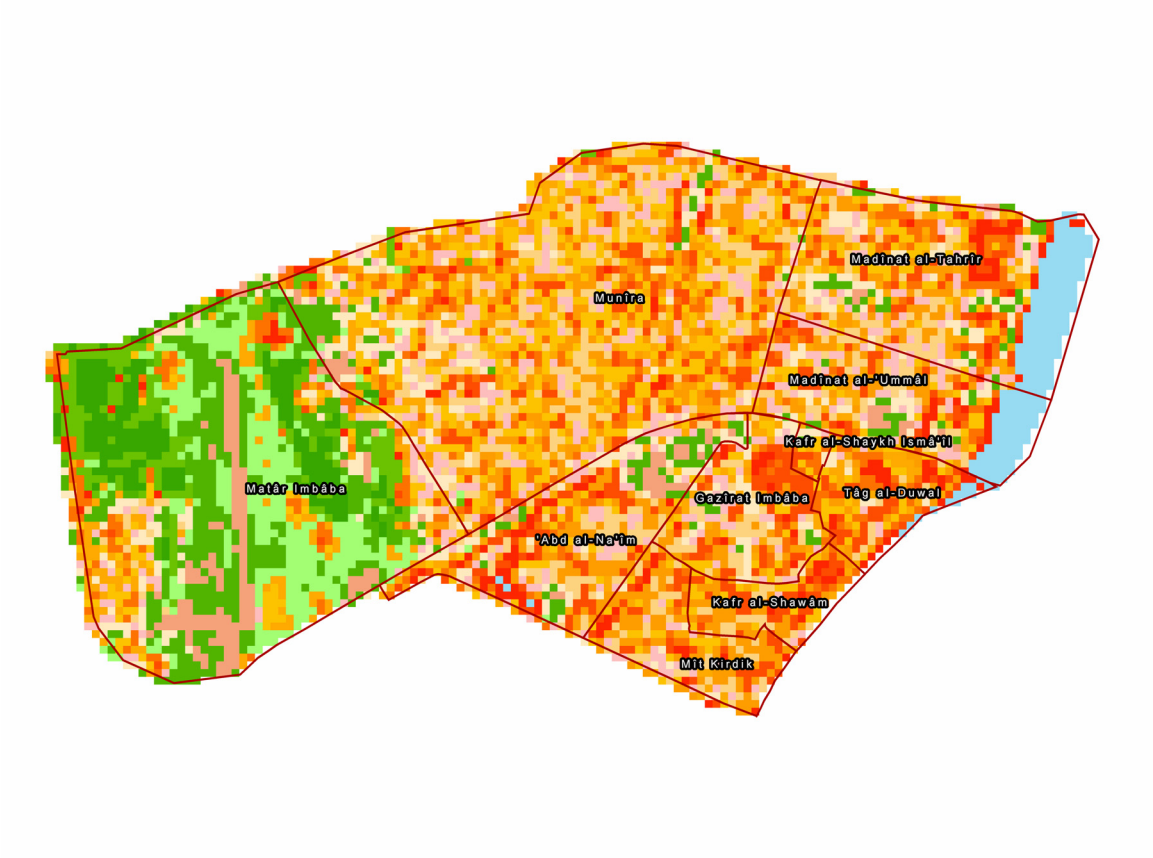

Figure 70. Classified Landsat image showing urban and agricultural landuses.

The image from 1999 shows Imbaba almost completely filled by development. A small area of agriculture remains on the east side of the airfield and on its west side a larger piece preserves the farming past. The great informal settlement that began as a small strip on the edge of Munira shiyakhat in the 1940s has expanded well beyond the confines of Imbaba.

Figure 71. Developed area from 1986 overlaid on 1999 satellite image.

The previous images show the transformation of Imbaba from a small agricultural village to a densely populated urban area, an integral part of the city of Cairo. In the next section will explore the demographic makeup of Imbaba.

Demographics of Imbaba

The next step in the study is to look at the population in the Shiyakhah that make up Imbaba. Factor analysis of selected attributes from the Census of Egypt of 1986 was used for this task. Two separate analyses were performed, one on attributes of religion,

education and types of employment. A second analysis was done on the attributes for age distribution.

Analysis of attributes for religion, education and occupation was intended to give a picture of social class distribution in the city and in Imbaba. The results of the analysis are shown in Table 2 below.

There are four factors with eigenvalues greater than 1 and these account for 79% of the variance in the data. Factor 1 has high component scores for high educational attainment, management positions and technical and scientific employment and an exceptionally negative score for illiteracy. Taken together these indicate upper class and upper middle class populations of technocrats. Factor 2 has high scores for religions other than Islam and Coptic Christianity. In the context of Cairo this indicates cosmopolitan populations possibly with many foreign born residents. Factor 3 has very high component scores for trades that are associated with the tourist industry, restaurants, hotels, commerce, but no particular input from educational factors. This may indicate lower middle class and working class residents who interact with foreigners comfortably. Finally factor 4 populations score high for service work and manufacturing, most likely working class jobs with little contact with outsiders and perhaps a more parochial view of the world. These are very rough characterizations based on census attributes that give little specific information about income or social class. Particularly in the data on employment categories there is no distinction between managers and workers in a particular industry. The fields for management lumps all industries together and the fields for particular industries lump all workers together (Abu-Lughod, 1971). They do

serve as a first approximation for identifying populations by class particularly for the educated upper middle and upper classes.

Table 2. Attributes used in Factor Analysis of Religion, Education and Employment. (Values less than 0.3 are removed from the matrix by SPSS.)

Rotated Component Matrix(a)				
	Component			
	1	2	3	4
other religion % of total		.776		
jewish % of pop		.671		
christians % of pop				
college and higher % of pop over 10 years	.573	.720		
university % of pop over 10 years	.856	.451		
illiterate % of pop over 10 years	-.911			
service workers % of total				.834
commerce % of total			.937	
middle management % of total	.797			
upper management % of total	.702	.656		
technical and scientific % of total	.921			
manufacturing % of total			.485	.533
trade, resturants, hotels % of actifs inscrits			.913	
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.				
a Rotation converged in 7 iterations.				

Table 2 shows the attributes used in the analysis and gives the rotated component scores for attributes scoring greater than 0.3. In the maps that follow the scores of shiyakhah on the various factors are shown. Figure 72 is an overview map of Cairo to orient the viewer to these maps. The extent of the built area of the city in 1999 is outlined in blue. Several landmarks are identified and the shiyakhah boundaries are shown.

In Figure 73 are the scores on Factor 1 for the shiyakhah of Imbaba. There are three zones that appear in this figure. In the northeast two shiyakhah show very high scores for highly educated technocrats while in the northwest just the opposite is the case with very negative scores on this factor. In the south a mix of slightly positive to slightly negative scores indicates a more diverse population.

Figure 74 shows the Factor 1 scores for the entire city to put Imbaba in context. The highest scores are in Heliopolis, Giza, Roda, the "Silver Coast" on the east bank of the Nile and Maadi and Helwan to the south of the city. The population of northeast sector of Imbaba is comparable in Factor 1 scores to these very elite areas of Cairo.

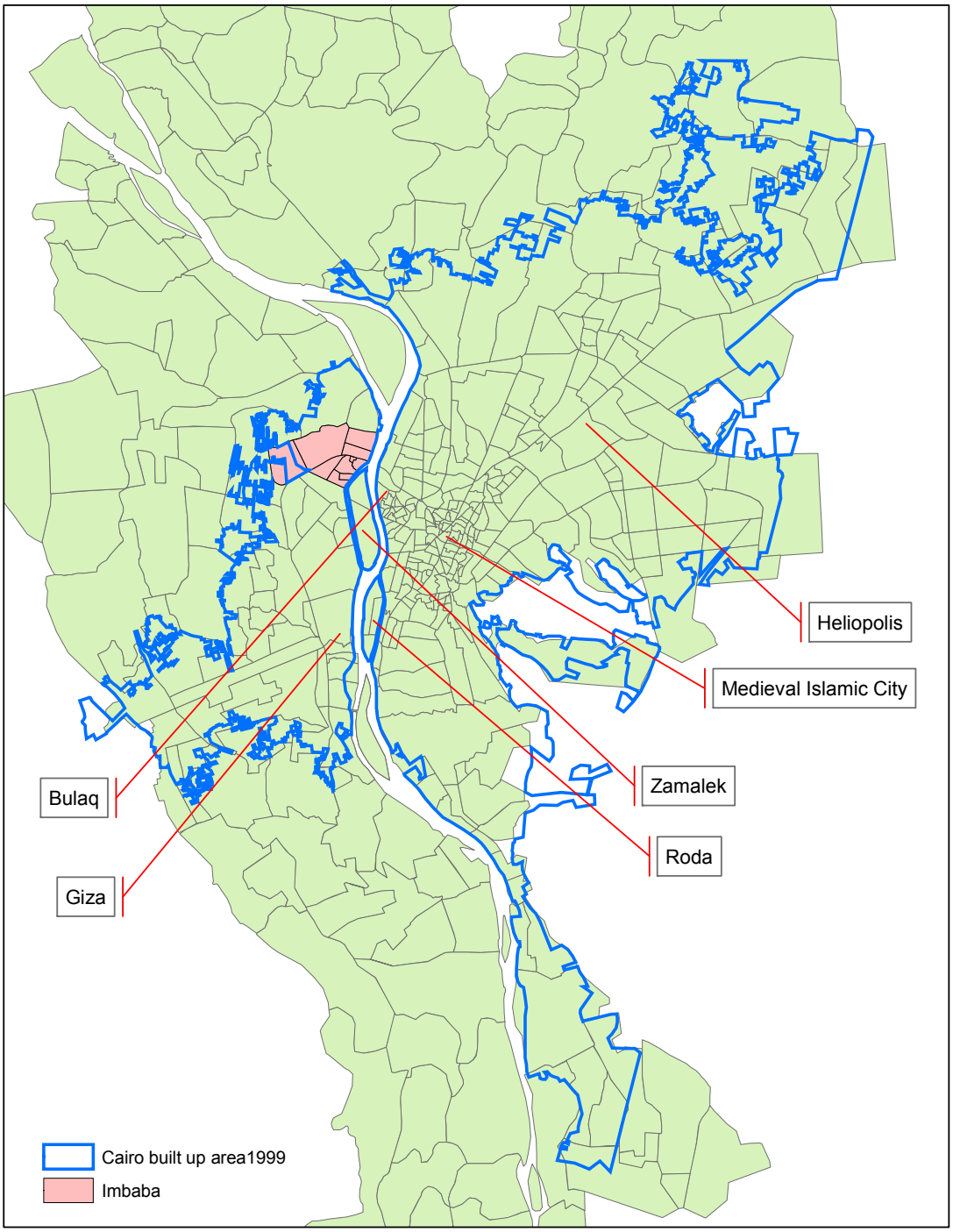

Figure 72. Overview of shiyakhah boundaries for Cairo.

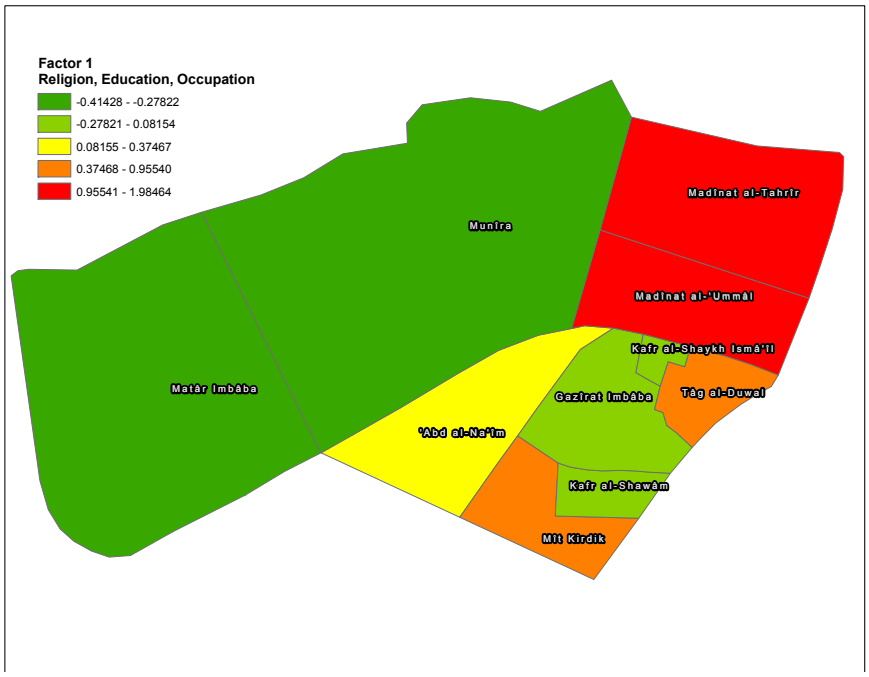

Figure 73. Analysis of religion, education, and occupation results for Factor 1. High scores indicate high status and high education level.

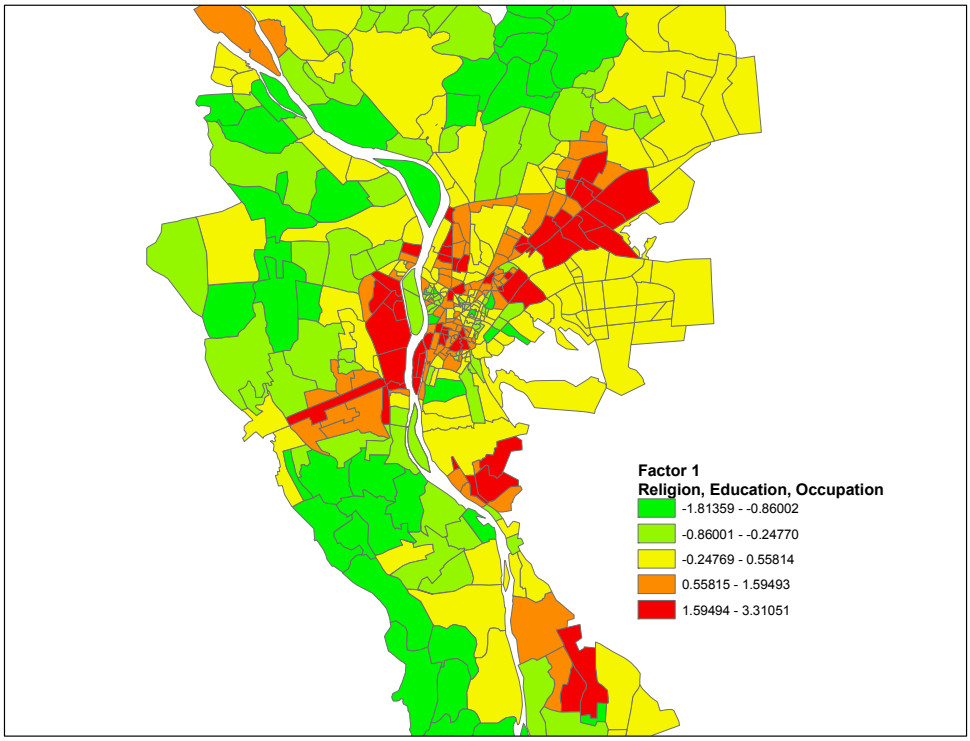

Figure 74. Factor 1, religion, education, and occupation for greater Cairo.

Factor 2 in this analysis, associated with cosmopolitanism, is shown in figure 75. Zamalek and the "Silver coast" areas near the old European inspired central city score very high on this factor. Heliopolis, Maadi and the area north of Giza also score high suggesting that foreigners live for the most part in the same areas that the Egyptian elites favor. In Imbaba this factor is negative to very negative. This suggests that the elites who live in Imbaba are Egyptian with little foreign admixture.

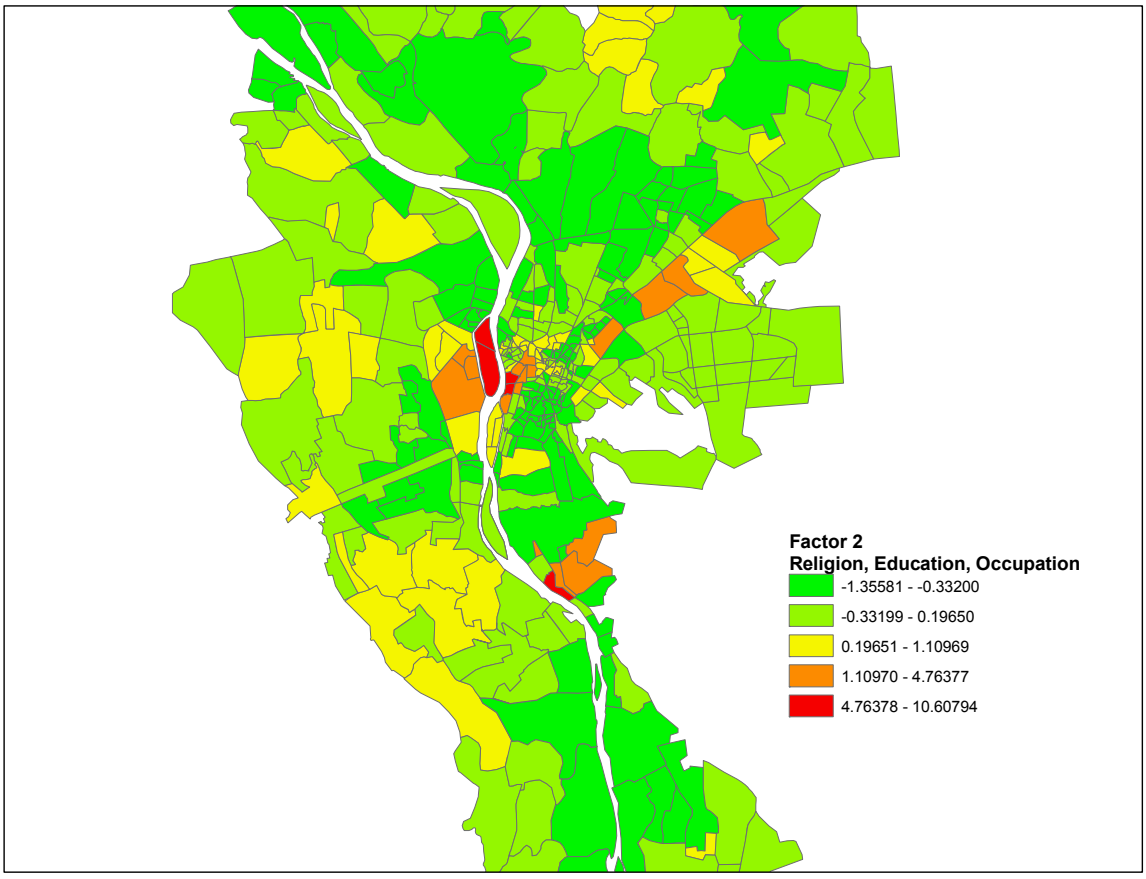

Figure 75. Factor 2, religion, education and occupation for Cairo as a whole. High scores show cosmopolitan population. Imbaba has very negative scores for this factor.

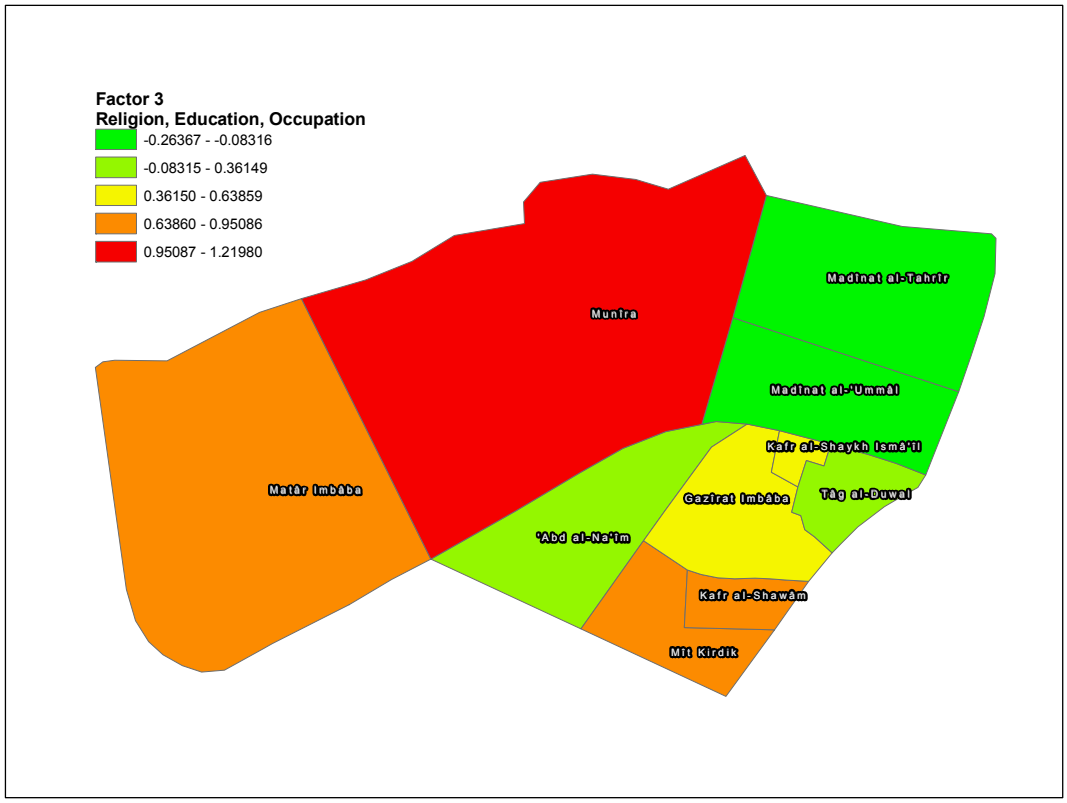

Figure 76. Factor 3 scores for Imbaba. High scores are associated with employment in the tourist industry.

Figure 76 shows the scores on Factor 3, associated with the working classes in the tourist industry. Munira scores very high on this factor but the shiyakhah to the east, which were identified as more upper class in the previous factor, here have very low scores. The area south of the railroad line again is a mixed area not scoring exceptionally high or low. To put this in the context of the larger city Figure 77 shows the overall results on Factor 3.

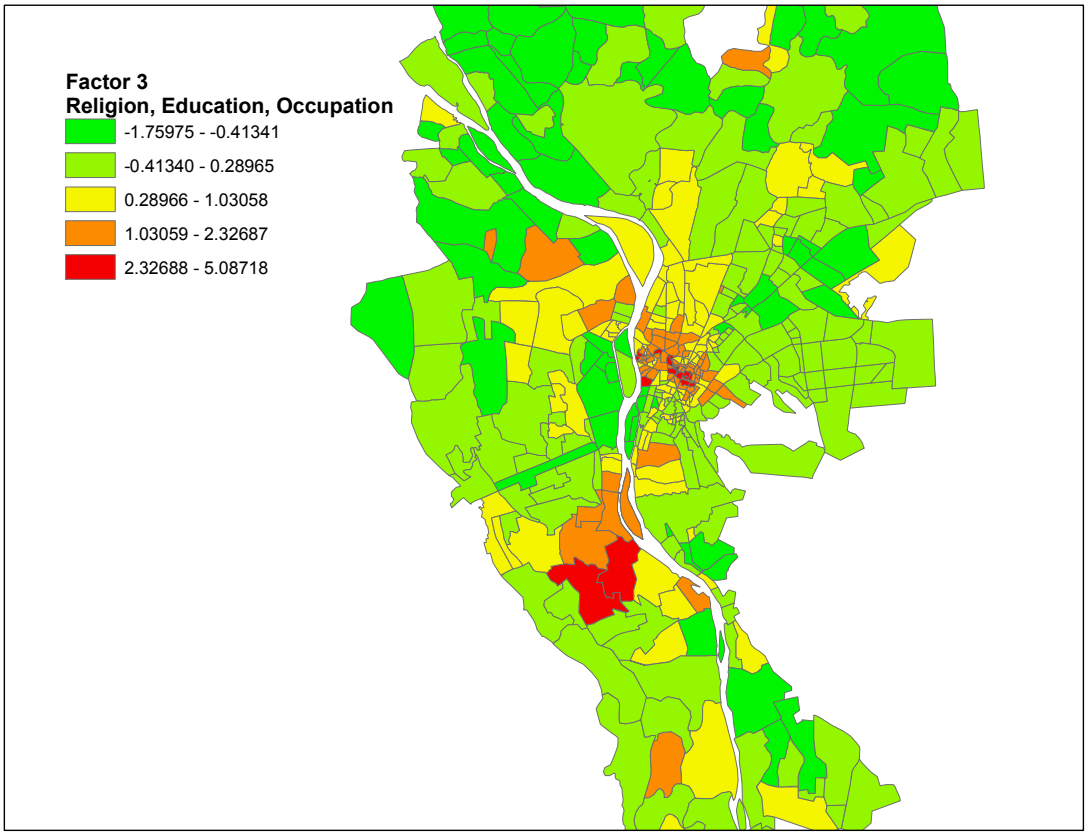

Figure 77. Factor 3 scores for Cairo.

Figure 78 shows the scores for Imbaba on Factor 4 associated roughly with working class neighborhoods in service industries and manufacturing. Here the highest scores are in Matar Imbaba, Kafr al Shaykh Ismail, and Abd al-Naim. Figure 79 shows this factor for the entire city and raises a problem with the interpretation of this factor as indicating working class population.

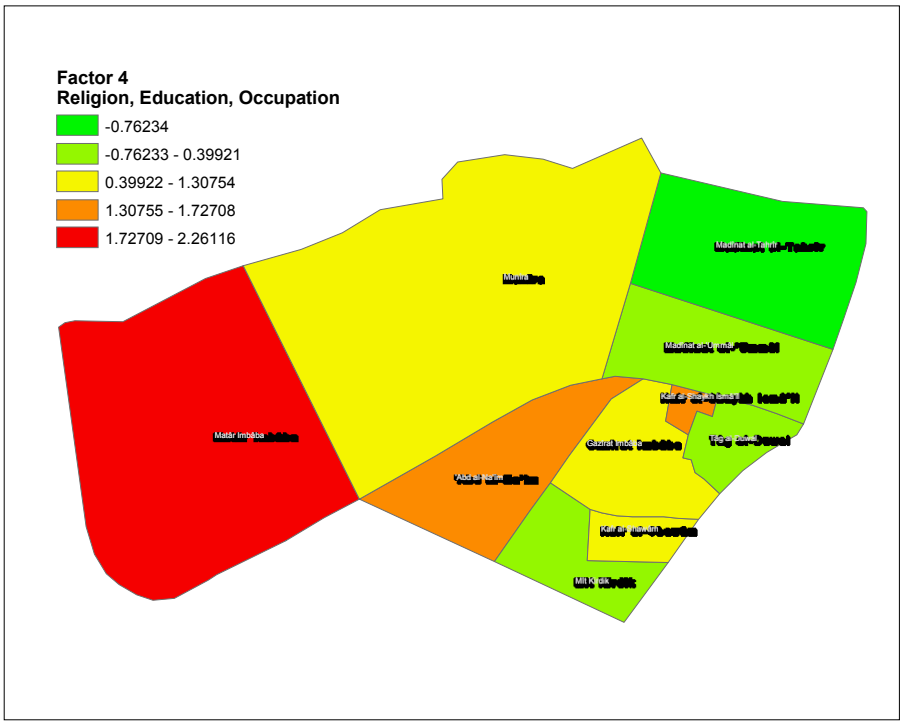

Figure 78. Factor 4 scores for Imbaba.

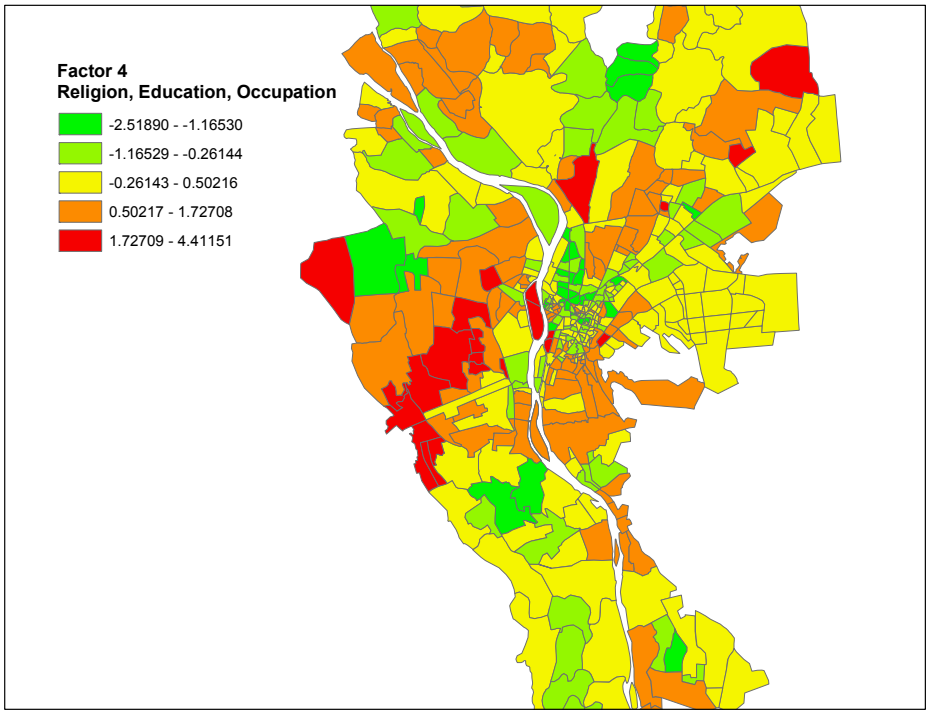

Figure 79. Factor 4 scores for the city

Zamalek and two shiyakhat on the "Silver Coast" show very high scores for this factor but they are not working class areas. This indicates a limitation in the attributes of the Egyptian census for determining class. The occupations are divided by type of industry but workers and management in a given industry seem to be lumped together (Abu-Lughod, 1971). With that caveat and the fact that each factor after the first represents less of the variability in each shiyakhat the characterization as working class seems to hold.

The second analysis performed using the 1986 Census data looked at age distribution. The rotated component matrix for this analysis is shown in Table 3. Factor 1 which accounts for 60.6% of the variance has very high component scores for age groups 40 and up, very negative scores for ages below 12, and a moderately high score for 20-30 year olds.

Table 3. Age groups for factor analysis of age distribution.

Rotated Component Matrix(a)		
	Component	
	1	2
A65UP_	.889	-.198
A60_65	.936	-2.767E-02
A50_60	.958	2.415E-02
A40_50	.706	.400
A30_40	4.419E-03	.931
A20_30	.678	.403
A12_20	-.121	-.749
A6_12	-.884	-.342
A0-6	-.904	-.269
Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization.		

This age distribution points to households that could be characterized as “empty nesters”, older population with fewer children, and young adults that haven’t started families yet.

Factor 2 in contrast shows strong scores in the prime child rearing years 20 –50 with the highest score in the 30- 40 age group. Figure 80 shows the factor1 scores for the City as a whole. In this map we see the areas most associated with older population are the oldest parts of the city and some of the most affluent.

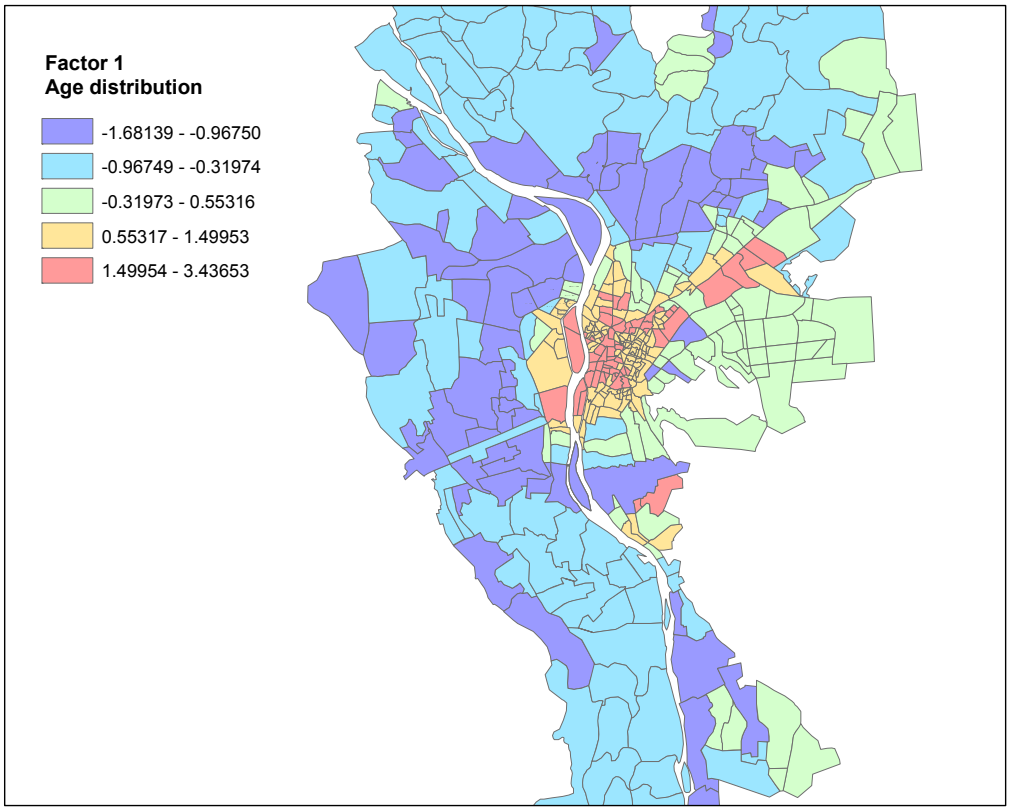

Figure 80. Age distribution factor 1 scores for Cairo.

The 19th century European influenced districts of Heliopolis, Zamalek, Roda and the central business area show the highest scores. The central districts of Cairo have been losing population in recent decades (Bayet and Denis, 2000). This Factor indicates that

the population loss is in younger age groups, leaving older residents behind. This central core is surrounded by a ring of shiyakhah with very negative scores.

In figure 81 we see the factor 1 scores for Imbaba. The three western Shiyakhat show strongly negative scores for this factor. These areas are actively growing in the 1980s and it seems reasonable that older population would not be characteristic of new communities. The highest scores are found in the oldest areas, most of those settled before the 1940s. This suggests that as families are formed they move out to the periphery of the city and leave the older central cores to the older population.

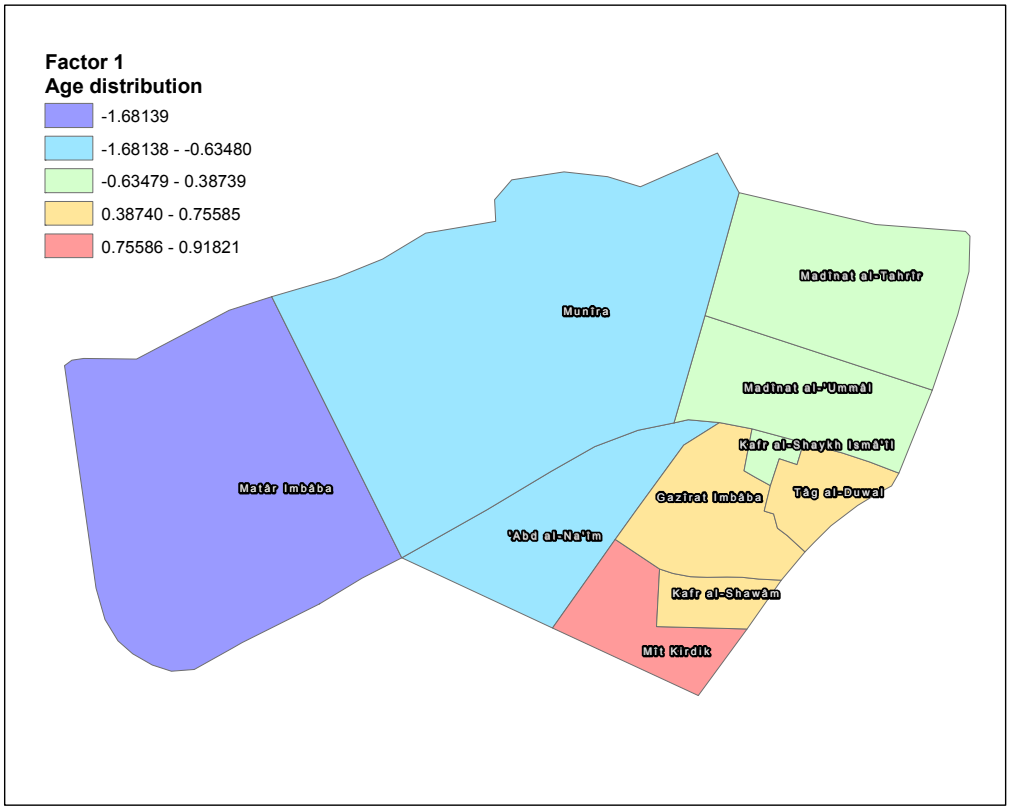

Figure 81. Age factor 1 scores for Imbaba.

In Figure 82 the scores for Factor 2 for age distribution are mapped for the city as a whole. This factor, which shows a strong trend toward family forming age groups,

might be expected to be a mirror image of Factor 1. There does seem to be a ring around the city of positive scores but as this is a narrower age range than that in factor one there is more variability possibly based on when each shiyakhat was developed. The highest scores seem to be in areas actively developing in the 1980s. The data for the analysis comes from the 1986 census. Areas which developed a decade or so earlier still show positive scores but not as strong.

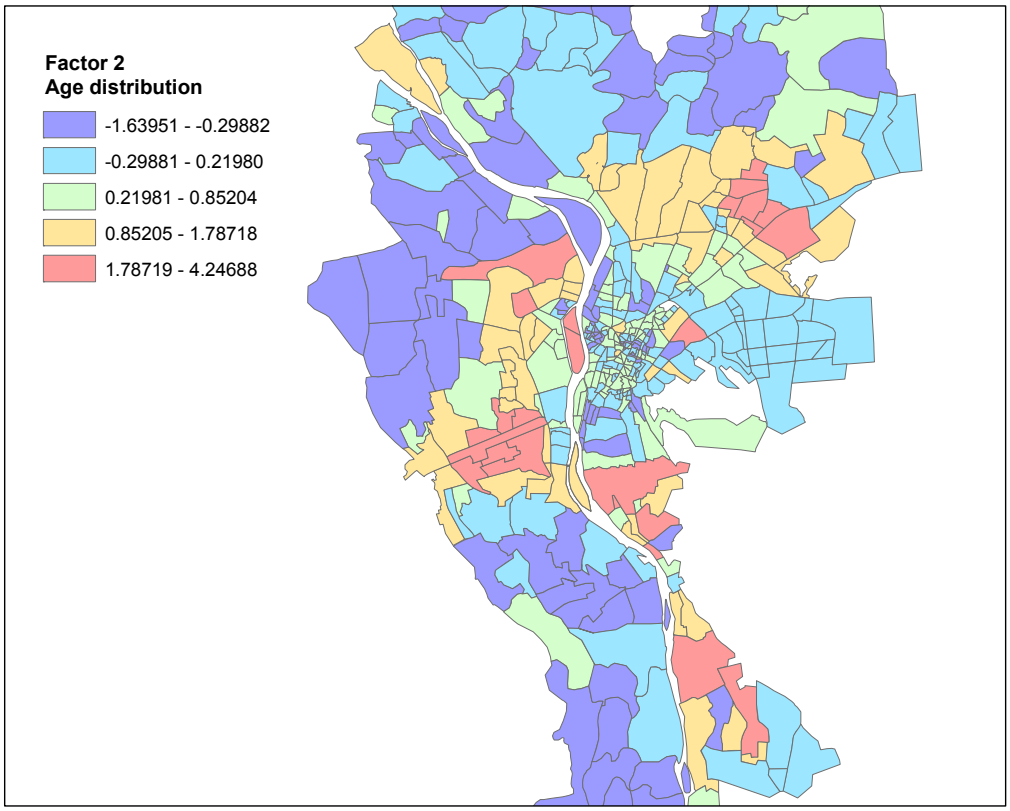

Figure 82. Age factor 2 scores for Cairo.

The maps of Imbaba between factor 1 and 2 show more strongly a mirror image. (Compare fig. 81 and fig. 83)

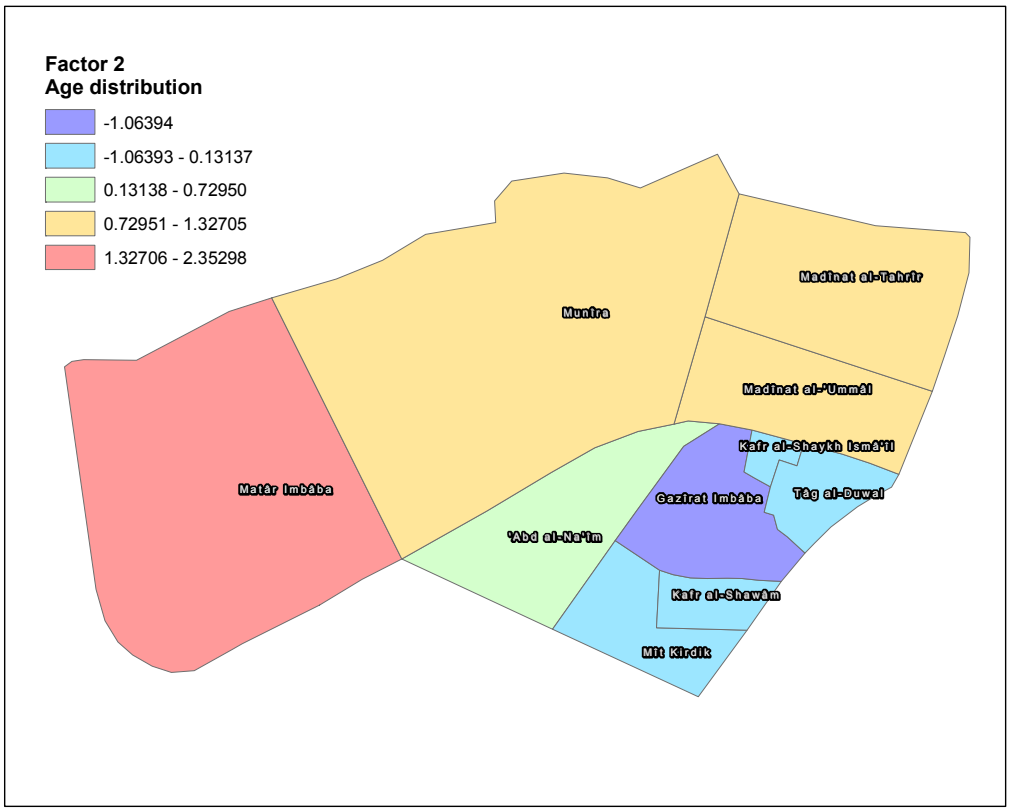

Figure 83. Age factor 2 scores for Imbaba.

North of the railroad the eastern shiyakhah, which experienced strong growth in the 1960s and 70s have fairly high scores on factor two. Matr Imbaba in the west, which had most of its development in the 80s, shows a very high score. This indicates that the prime population for new development in these areas is in the 30 to 40 age range and that once established they grow older with their neighborhoods.

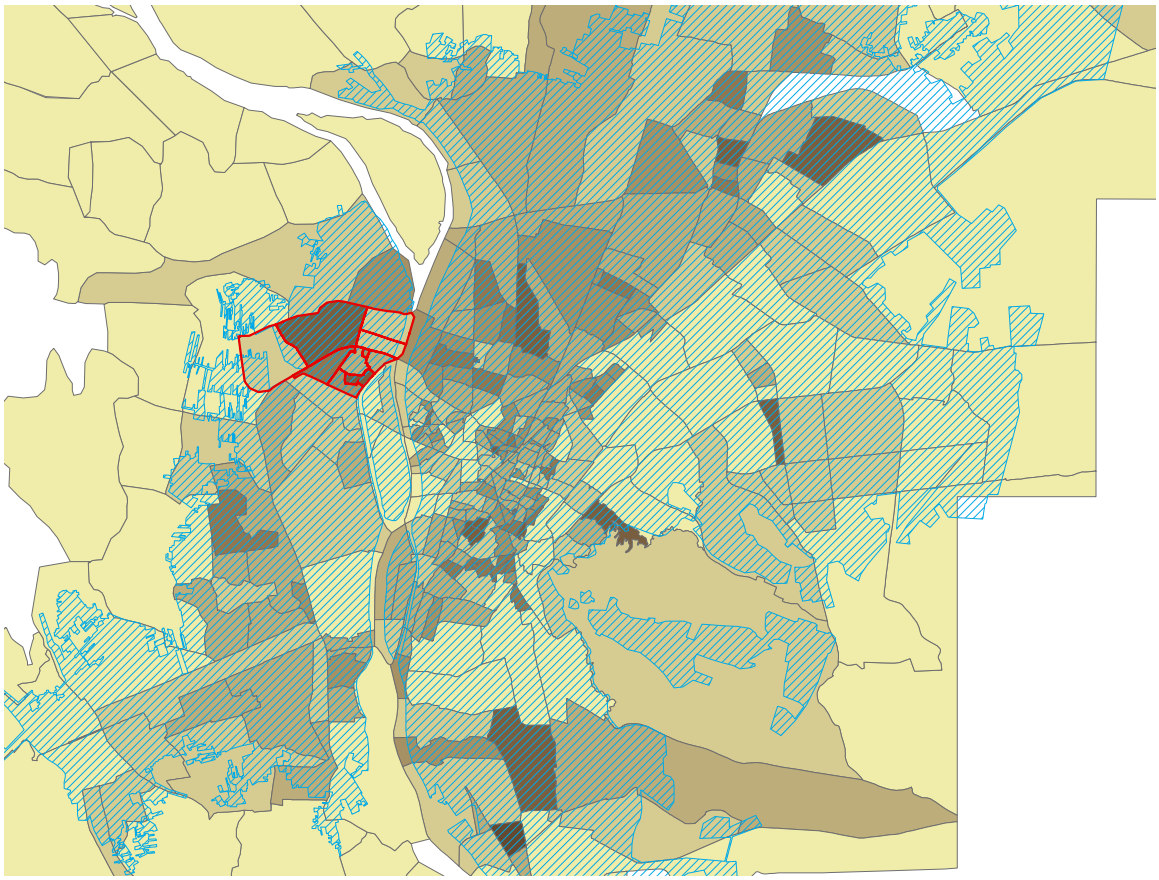

Figure 84. Population density in Cairo 1996.

In figure 84 we see population density for Cairo from the 1996 census. The blue hatching is the limits of the built up area of the city derived from the 1999 satellite image. Imbaba is outlined in red. Munira shiyakhah shows up as one of the most densely populated parts of the city but the remainder of Imbaba varies in density from very high to low. Using the shiyakhah boundaries to calculate density understates the actual value because small parts of Imbaba were still agricultural in 1996 and other areas were industrial or had institutional land uses. In Figure 85 the density is shown using boundaries redrawn to account for land use and shows the relative density within Imbaba.

Figure 85. Population density in Imbaba 1996.

Figure 86 shows the change in population between the 1986 census and 1996 census.

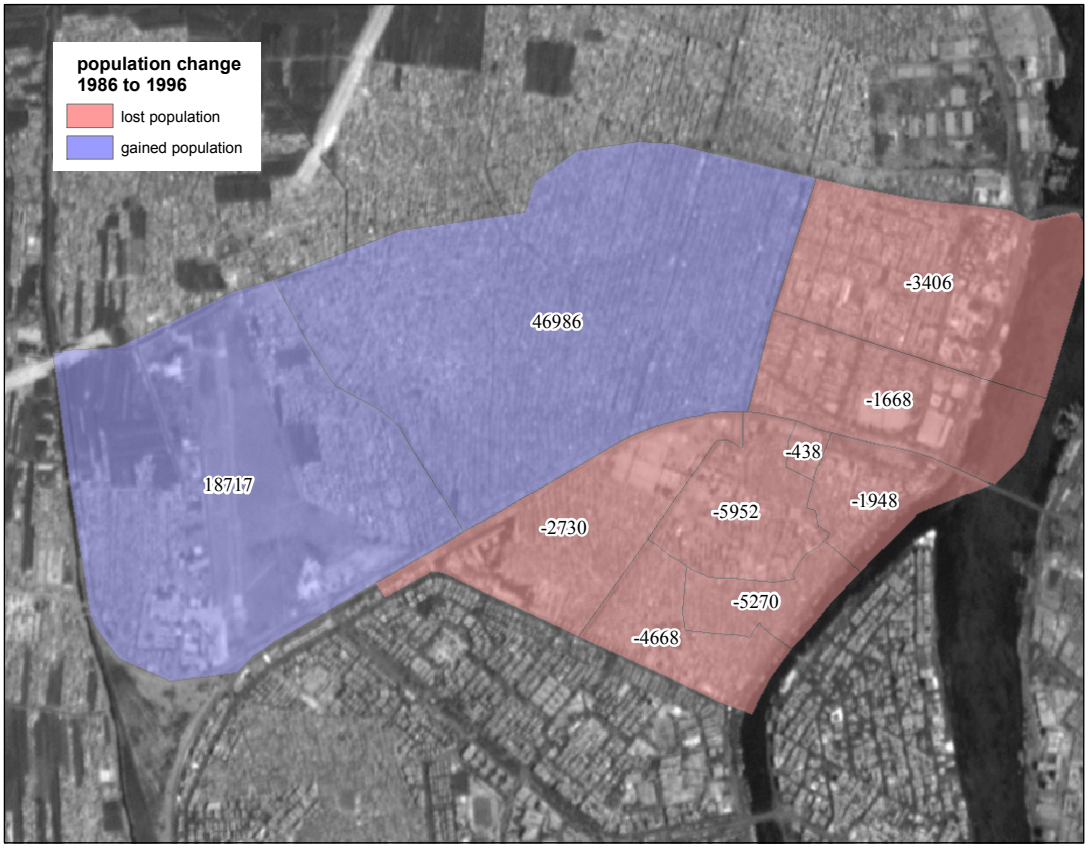

Figure 86. Population change in Imbaba 1986 to 1996.

Imbaba Development Zones:

Traditional development:

The detailed analysis of the building history of Imbaba shows that there are areas of each of the development types that are the focus of this study. This section identifies those areas and then looks closely at each type to discern any patterns in their development. Figure 87 shows the area of traditional Islamic development.

Figure 87. Islamic development area.

The conventional view of traditional Islamic development is that it arises from a process of evolution, that the winding streets and dead end alleys come as a result of encroachments over time on a more orderly pattern. This has clearly happened in the old city of Cairo but the building of the traditional area of Imbaba may represent an alternative path. Figures 21 and 22 above show the shifting in the course of the Nile.

This shift may have caused major parts of the village of Imbaba to be rebuilt. In figures 24 and 25 the newer additions to the village still have the look of traditional developments. However Figure 27 also a map of the old village shows an area of new construction built on a clearly different pattern, one of straight streets without dead ends. If this is correct there seems to have been a shift in the early 20th century in how residential areas were laid out. The evidence here is not solid however. The rebuilding of the village is based on the comparison of two maps, Napoleons map of 1800 and the Survey of Egypt map of 1918. The map of 1918 when overlaid on recent satellite images shows excellent agreement on the layout of streets. In the map of 1800 the French cartographers were mainly concerned with the city of Cairo on the east bank of the Nile. When that portion of the map is placed on a satellite image it also proves to be quite accurate in the location of features but the Imbaba portion of the map, on the west bank of the Nile, may not have received the same attention to detail that the city of Cairo received. (See figure 14 above)

French cartography was quite advanced at the period of the survey of Cairo. Trigonometric geodetic methods had been pioneered in France in the 17th century (Konvitz, 1985). The survey of Cairo was done by establishing a base line and then creating a chain 58 triangles covering the city using features such as minarets as triangulation points (Warner, 2005). This provided a basis for very accurate local surveys but probably didn't extend to Imbaba. There is no way to confirm the accuracy of the villages location in 1802 and determine if the conclusions about the changes in Imbaba village are valid.

Assuming there was a change in the way traditional building was done at the opening of the century 20th this may have implications for the building of informal developments. The forces that caused a change in 1900 may be shaping development in the 1930s and 40s when the Ashwaiyyat begin to be built in Imbaba. The change that seems to be influencing the shape of the new part of the village is that it is built in agricultural land that has been constrained by the irrigation system that British engineers built in response to the Aswan dam. This will be explored in more detail in the discussion of informal development.

Formal development:

The area of formal development in Imbaba is shown in figure 88.

Figure 88. Planned development areas in Imbaba.

Even on this low resolution image from 1999 the areas of formal development look different than the rest of the study area. These differences in layout of streets and size of buildings are a large part of the identification of planned development. In Imbaba there are two areas of formal building from different periods of Cairo's history. The large block to the north in Figure 87, Madinat al-Tahrir and Madinat el-Ummal, was developed sometime between 1941 and 1962, as seen from the aerial images. (Figures 43 and 44 above) Fortunately references in the literature can pin the date down more precisely. Volait identifies the designer as an English trained Egyptian employee of the Tanzim department. (Nielsen, 2001 p 63) The developments were intended as low income housing and building began in 1947. The development was scaled back in 1952 and redesigned in 1954 after the Revolution but the design is very much of the Colonial period (Nielsen, 2001).

Figure 45 above shows the layout of this development with set asides for schools, mosques and recreation. This prominent inclusion of supporting services in an area is a clear indication of prior planning. One other indication of planning in these developments is that the new land use is not based on the shape of the previous land use. Figure 89 shows the outlines of the buildings of Madinat al-Tahrir and Madinat el-Ummal over laid on a map of the previous agricultural field boundaries. The orientation of the buildings is not consistent with the fields and some of the buildings overlap pre existing canals and pathways.

Looking at the demographics of the two shiyakhah that comprise the development shows that the intended use as low income housing was not achieved (Raymond 2000). The map of Factor 1 scores in the analysis of education, religion and occupation from

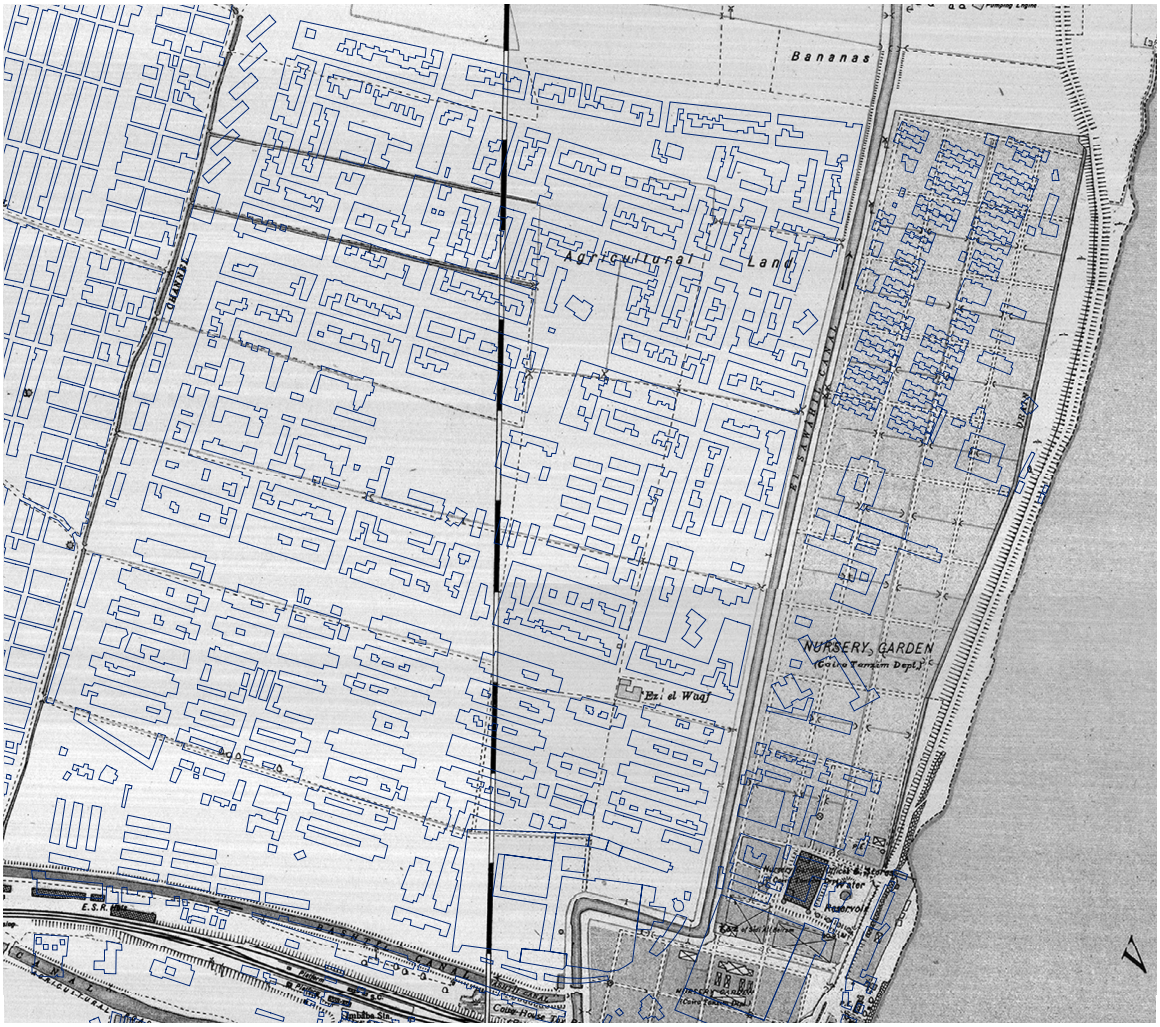

Figure 89. Building footprints from 1977 over laid on 1936 map of agricultural fields.

figure 72 gives very high scores to these shiyakhah. This indicates a tendency for the residents to be highly educated in scientific and technical fields and to be middle and upper management. These residents are probably in the elite of Egyptian society.

Figures 84 and 85 show very low density in these neighborhoods which also seems to be associated with higher class residential areas.

Unfortunately the building of these areas comes in a period that does not have imagery or maps that capture the development in progress. This is a real drawback for the methodology of this study in trying to determine the pattern of the development. It is possible to look at similar developments in other parts of the city that happen to be captured in a map or image in the middle of the building process and make some assumptions about how these projects were built. It is likely that the order of building was that a block of land was cleared, roads and other utilities were put in and then the buildings were constructed. This order can be seen in Garden City and Zamalek as they were developed. This contrasts with the informal developments where the buildings are constructed first and the roads and other infrastructure follow.

The second zone of planned development in the study area is quite different from the first. Figure 90 shows this area. It is a dense collection of mid-rise apartment blocks of a style that has become associated with Nasser and Soviet influence in the Egyptian revolution.

Figure 90. The green areas are tower blocks built between 1962 and 1977.

For this phase of Imbaba's development there is much better evidence in the study's data sets. Figure 91 shows the five time periods that cover this development. In each frame the buildings completed in the previous time period are highlighted. Also highlighted in green are schools in the area.

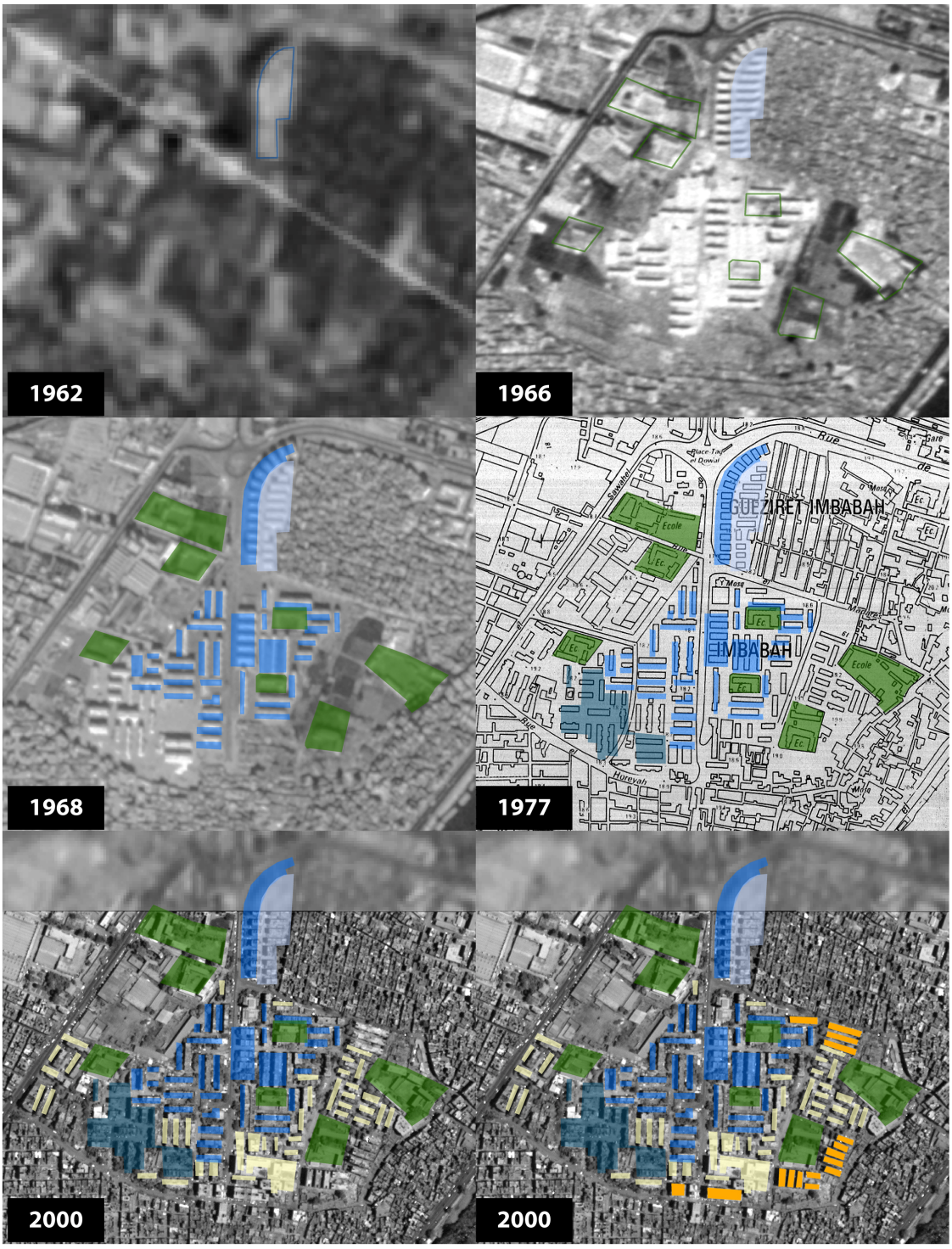

Figure 91. Stages of building Nasserist housing blocks.

It is easy to distinguish this new type of building from the surrounding areas. Inspired by Soviet style apartment blocks they replace the English style of planned town that was built before the revolution. In this area of Imbaba about half of the apartments were built before the outbreak of the 1967 war with Israel, but construction continued even in the period between 1967 and the resumption of hostilities in 1973. During the interwar period Egypt was on a constant war footing and it is surprising that resources were found to continue building housing (Sims, 2003).

Like the planned developments in Madinat al-Tahrir and Madinat el-Ummal these Revolutionary period developments were laid out with out any reference to the previous agricultural land use. (Figure 92) Unlike the previous development there does not seem to be an over all plan for the area. New tower blocks are put in as time goes on without concern for the orientation of the preceding buildings. The only common element is the tower block style.

The location of schools surrounding these new developments shows that infrastructure is being provided for the inhabitants much as in the earlier planned development. The demographics of this development area are difficult to characterize based on the factor analysis of the census. The area is slightly negative for the factor indicating high educational and occupational status. (Figure 73) It is slightly positive for the factors indicating working class status but nothing stands out as clearly characterizing the neighborhood. (Figures 75 and 78)

The common traits of the planned developments are that the layouts of the buildings are not influenced by the previous agricultural land use and that amenities such as schools and mosques are designed into the developments at an early stage.

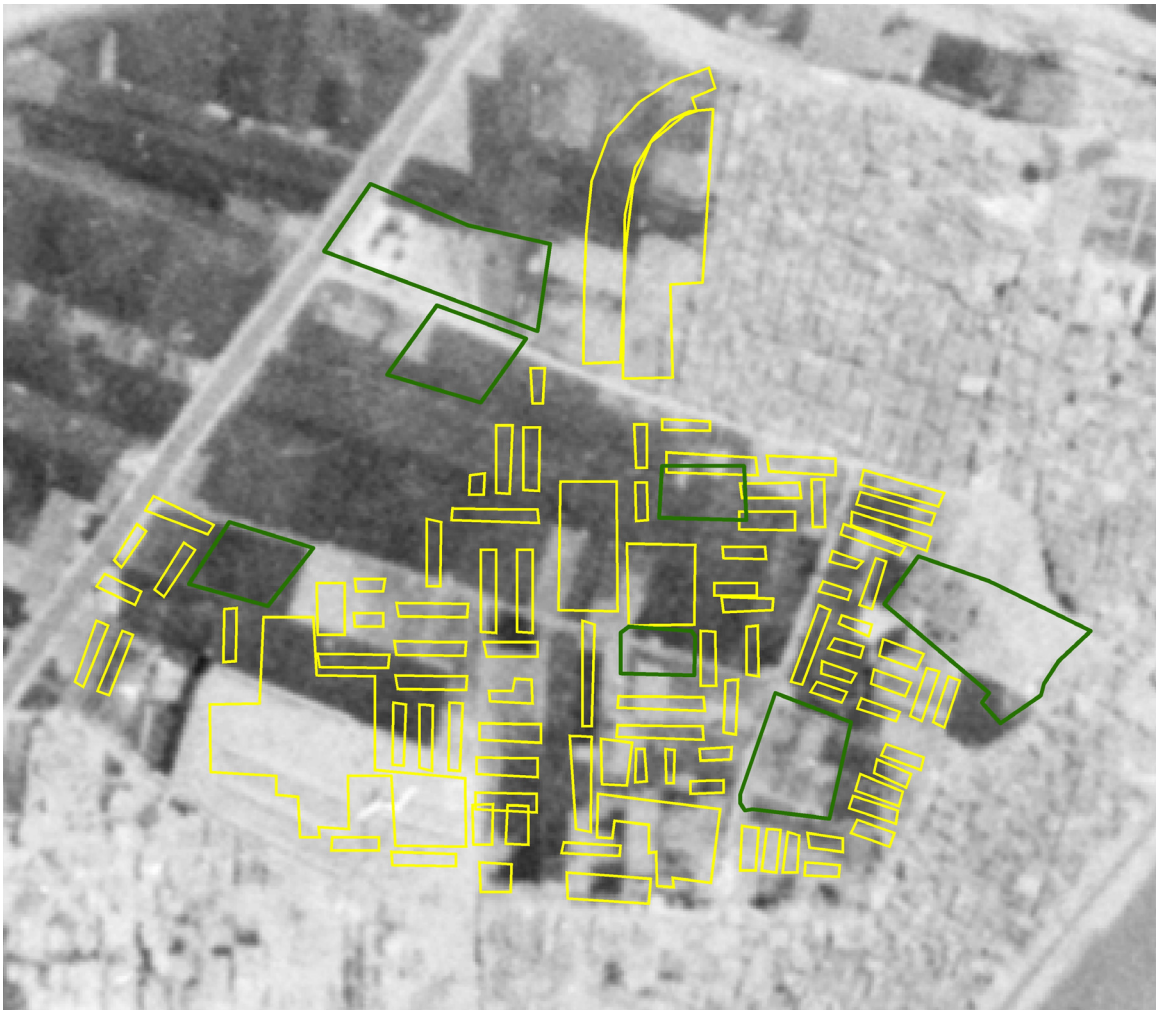

Figure 92. Outlines of Soviet style apartment blocks over a 1941 photo showing the shapes of the agricultural fields.

Unplanned / Informal Development:

Imbaba is identified by many sources as a focus of informal development (Bayet and Denis, 2000). The major zone of informal development in Imbaba is shown in figure 93.

Figure 93. Informal development area of Imbaba.

Figure 94 shows the progression of building in this zone. The first construction began between 1936 and 1941 along the eastern edge of Munira shiyakhat. Development then progressed from east to west accreting on to the previous edge or growing from roads in a dendritic pattern. Figure 95 shows a detailed view from 1968. The new developments follow the field boundaries leaving some land as agriculture.

This pattern agrees with Sims' description of the layout of informal housing following the irrigation system (Sims, 2003). Raymond observes that the irrigation canals become the sewers and foot paths become the streets for the new urban inhabitants (Raymond, 2000). The sharp division between developed and undeveloped land reinforces the assertions that the builders are land owners and not squatters. Squatters would have little interest in respecting property lines (El Batran and Arandel, 1998).

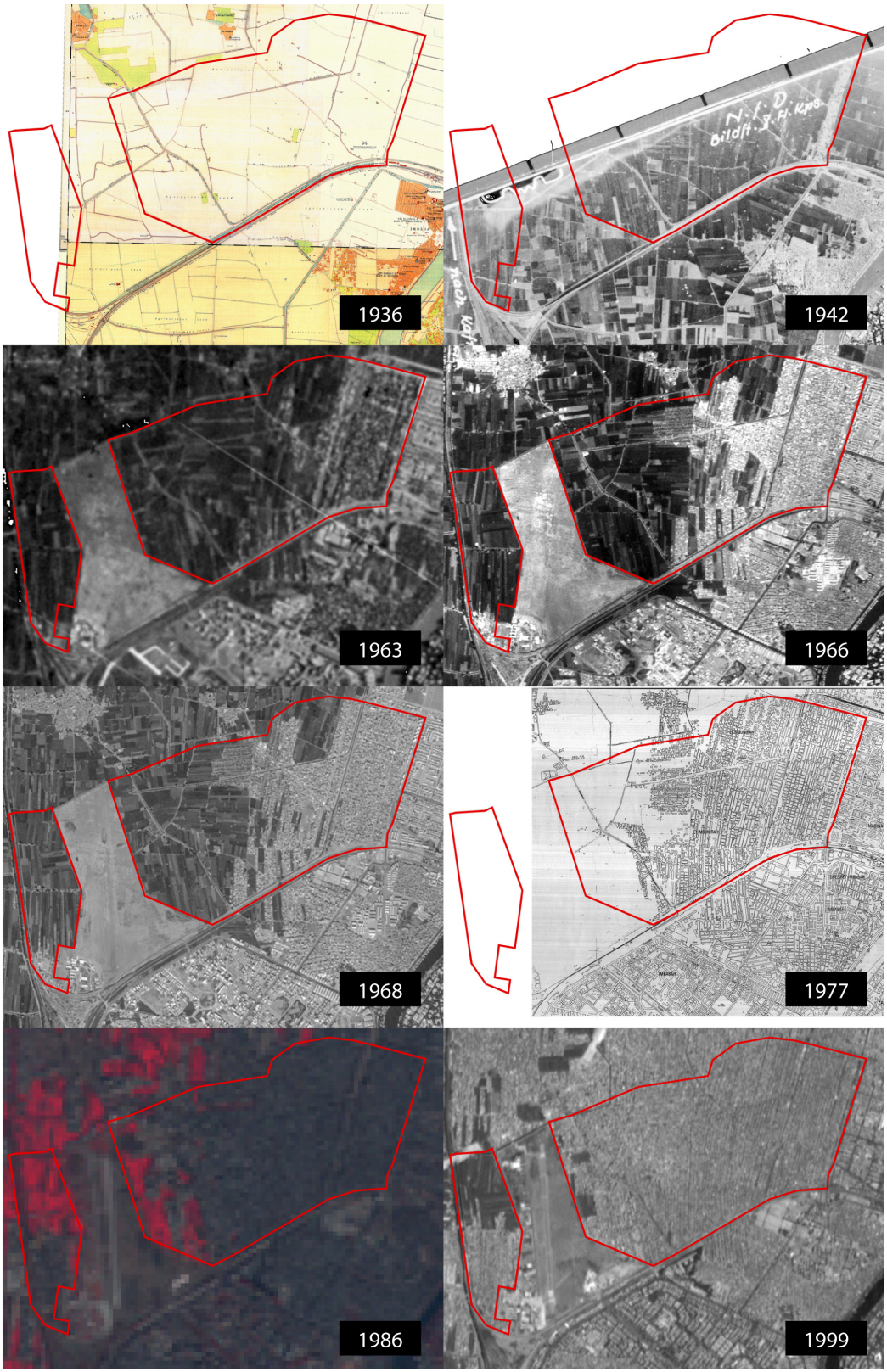

Figure 94. Progression of building in Imbaba Ashwiyat.

Figure 95. Detail of informal development 1968.

The main irrigation canals become the principal transportation routes in the informal areas. In Figure 96 the canals, digitized from the 1936 map, are shown on the 2005 satellite image. In the informal areas the major streets match the old canals exactly.

Sims places the beginnings of informal development in the 1960s (Sims, 2003). The case of Imbaba seems to show that rather than beginning as recently as the 60s there was a continuity between the expansion of the agricultural village before World War One and the start of informal development north of the railroad line in the late 1930s. The development accelerated in the 1960s. Then the era of greatest expansion came after the Infitah opened the door to remittances from outside Egypt (Sims, 2003). As workers had more money to invest in housing the informal area of Imbaba filled completely in the1980s and informal development moved on toward the north.

The demographics of the informal area are working class. In the factor analysis of education and occupation Munira shiyakhat has a very high score on factor two that identifies workers in the tourist industry. In contrast it scores very low on factor one which indicates educated middle and upper classes.

Figure 96. Roadways replace canals in informal areas.

The factor analysis for age Factor 2 represents the child rearing age groups. The scores for this factor increase across the informal areas from east to west in the same direction as the growth of the developments. (Figure 82) This helps characterize the builders of these developments as new families looking for an affordable way to set up a household.

The pattern of development for the informal areas is shown to be very distinct from the planned communities. In the formal areas the new development is divorced

from the previous use. In the informal areas the agricultural fields and irrigation canals shape the new developments completely. The advantage of the informal developments for the builder is that land costs are cheaper than in formal developments (El-Batran and Arandel, 1998). Much of the savings comes from the lack of infrastructure costs to the subdivider. In the planned developments the builder bears the cost of streets, sewers, water and electric utilities. The informal developer on agricultural land uses the irrigation system as a ready-made sewer. Once the canal is covered over it can be used as a street that does not require any of the developers land to provide. The costs of this infrastructure were borne by the cotton growers and the English colonial government that built the canal system at the turn of the century.

The informal pattern of development also seems to be one of accretion on to already existing ashwaiyyat. This may also be explained by the availability of electrical service from nearby illegal users. This ability to externalize the costs of infrastructure by adaptively reusing the existing irrigation system may be the primary driver in the loss of agricultural land to development.

Chapter Five.

Conclusions:

This study set out to answer three questions using a methodology based on the techniques of aerial photo interpretation. First, are there distinctive patterns in the rate, timing, and shape of growth that distinguish informal development from the other development types? Second, can these patterns give insights into the forces shaping informal development in Cairo? Finally, can these patterns be used to identify the extent of existing informal developments and help to predict the future directions of their growth in the city? It was partially successful and the effort helps to show the potential benefits and limitations of using airphoto interpretation on a time series of images and maps.

The first question proved the most problematic. There are distinctive patterns that distinguish informal development from the other development types. However gaps in the temporal coverage of the data in this study make some of the conclusions about the patterns speculative. The analysis of formal development was uneven because of this problem. The developments of the Revolutionary period could be seen in excellent detail. The Corona spy satellite images from that era were of very high resolution and were separated by only a few years. The maps of the area dating from before and during the period of development were of large scale and seemed to be very accurate. These ideal conditions didn't exist for any other time period. In contrast the formal developments of the Colonial period took place during a twenty-year gap in the image and map record. The dynamics of building this type of development could be inferred by

looking at similar developments in other areas of the city but that assumed similarities that may not be valid.

The building of the informal developments extended over a longer time period than either of the formal developments so more of the data layers could be used in their analysis. The timing of building could be discovered fairly accurately but the scale of building in the informal developments is so fine that only the highest resolution images could show them in detail. Fortunately the patterns seen in the 1960s informal areas were similar to that seen in the 2000 – 20005 images so it is safe to assume that this is a real pattern of the type and not of the times.

The formal and informal development types were found to exhibit distinctive patterns in their construction. The formal developments were built in large blocks divorced from the previous land use. The informal developments grew out of the existing landuse patterns of individual fields bounded by irrigation canals. The formal developments include provision for infrastructure in their plans. The informal developments were built without any infrastructure at all. The traditional development style has a very distinctive visual pattern that distinguished it from the other types but there is no data in the study that points to the causes of the pattern.

The second question, can the patterns of informal development give insights into the forces shaping the development, can be answered with some confidence. Several characteristics of the pattern give clues to these forces, the timing of the building, the shape of the developments while they are being constructed, the types of buildings that are built and the demographics of the builder/residents.

The timing of informal developments observed in this study was not anticipated from a review of the literature. The impression from previous studies was that informal development was a recent phenomenon beginning perhaps in the 1960s. The picture that emerges from the maps and images is one of continuity in time between the traditional village building and the first appearance of recognizable informal development. The maps from the 19th century show the end of a tradition of building on a pattern of winding, narrow, dead-end streets that had been in consistent use for 1200 years. The maps from the early 20th century show the beginnings of a new pattern of rectangular blocks based on the shape of field boundaries in the former agricultural land. (Figures 23 and 27) After the change this new pattern has been consistent for 90 years.

In every thing but shape informal developments and Traditional developments are much alike. They both evolve over a long period by the process of individual builders putting up one building at a time. They are built without regulation by a government, relying on a traditional code to resolve conflicts between neighbors. They are subject to the same climatic forces. Transportation technology has changed but that has not affected the width of the roadways, which are narrow in both.

One clue lies in the feature that is carefully preserved in the new informal pattern, the irrigation canals from the former agricultural use. A constant in all human settlements, especially ones as dense as Cairo, is the necessity of disposing of human waste. The canals provide a ready-made sewer system to solve the problem. This raises the question of what was the traditional solution to waste disposal? Did European influence and the British effort to build sewers in Cairo disrupt a system that was in place? What ever the cause it seems that one of the forces that shapes the informal

developments of the 20th century is the adaptation of the irrigation system into a low cost sewer system, at least one whose cost is low to the builders of the development.

In the process of building on this new rectilinear form another pattern emerges that gives clues to the forces shaping the development. The agricultural land is converted to residential uses one field at a time. This leads to a ragged edge of urban development extending into the agriculture. (Figures 58 and 95) This pattern suggests that the new residents are respecting property ownership rights. Squatters, invading land against the owners will, would have little reason to avoid one field in preference over another so this pattern suggests that the new residents are either buying or leasing their plots. If the new occupants are buying this reinforces the appeal of the agricultural land with its readily adaptable infrastructure, which lowers the cost of development.

The types of buildings in the informal developments also reveal a great deal about the nature of these areas. The common building is very substantial framed in poured concrete and multi storied. This is quite different from the tarpaper and tin shacks usually associated with informal developments in other places (Dare and Fraser, 2001). These buildings represent a substantial investment for the builder and that reinforces the idea that the resident owns the land and the building.

The demographics of the informal areas give the final clue to the forces driving this type of development. The tendency for the residents to be between 20 and 50 years old with a substantial peak at 30 to 40 indicates that the motivation is household creation to start families. The trend of the last two censuses of Egypt showing that the inner city is losing population (Bayat and Denis, 2000) and the factor analysis showing that the

inner city population is ageing supports the idea that couples are moving out to the informal developments to raise families.

The picture that emerges is that the informal developments are the Egyptian version of Levittown. They provided the only affordable way for an Egyptian of moderate means to have a home to raise his family. That rather than ruralizing the city by an influx of traditionally oriented peasants from the countryside the exact opposite is the result. Traditional extended families may be breaking up as the younger generation moves out to the "suburbs" leaving the parents and grandparents in the core of the city.

The last question, can these patterns be used to identify the extent of informal developments and predict their future growth can also be answered positively but with a twist. The ragged, dendritic, leading edge of informal growth is very distinctive and can be seen in other areas of the city suggesting that they are experiencing this type of development. The close relationship between informal building and the shape of the former agricultural land use allows early maps to be used to identify areas of informal development by comparing the field boundaries to the shape of the developments and to distinguish them from earlier traditional building and formal development.

Predicting future development directions is difficult to test because there seems to be no further informal development going on. Though there have been may attempts to limit the growth of informal areas and so limit the destruction of agricultural land they had usually meet with little success (El-Batran and Arandel, 1998). But a new law of 1996 which moved criminal jurisdiction for building of informal housing to the military seems to have been effective (Sims, 2003). A comparison of the IRS satellite image of

1999 with a Quickbird image from 2005 shows almost no change in the area of informal building in the agriculture.

This study raises several questions that could be the source for further research. If informal development has been an outlet for new families to find housing what has replaced it in the last decade when the spread in informal developments has been slowed? What has been the effect of informal developments on the traditional Egyptian family unit? Finally is there a connection between traditional development and 20th century informal development?

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Appendix 1
Overview of development in Cairo/Imbaba.

Medieval to early modern period	Colonial period	Revolutionary period	Infitah / Openness period
Formal developments: Ismail begins building the European inspired central business district.	New developments are modeled on the English Garden City movement. Two formal developments are begun in Imbaba.	Soviet inspired tower blocks are the dominant form of public housing.	New cities are built in the desert outside of Cairo to absorb increases in population.
Informal developments Medieval village may have relocated to accommodate changes in the course of the Nile.	Seeds of Ashwiyyat begin to form outside Imbaba village.	Informal developments expand in Imbaba possibly absorbing population displaced by Israel's seizure of the Suez canal.	Capital flowing into Egypt from workers remittances is invested in expansion of informal developments.
Cairo: Medieval Cairo grows out of Al Qahira. Napoleon invades Egypt in 1798.	Aswan dam is built in 1902. Bridges across the Nile in 1907. The tram system is built between 1908 and 1917.	Wars between Egypt and Israel dominate. Arab socialism guides the economic system. Aswan high dam is built.	Opening to the western economies brings in tourist income to the country. Egyptian workers abroad send capital back to their families.
Imbaba: Imbaba village is built. It probably serves as a collection point for agricultural goods from the west bank of the Nile.	The village begins to expand. Imbaba market and the men's hospital are built.	Majority of main irrigation canals in Imbaba are converted to roadways.	No new formal development is built in Imbaba. Informal development continues until the entire qism is developed and building expands to the north of Imbaba.